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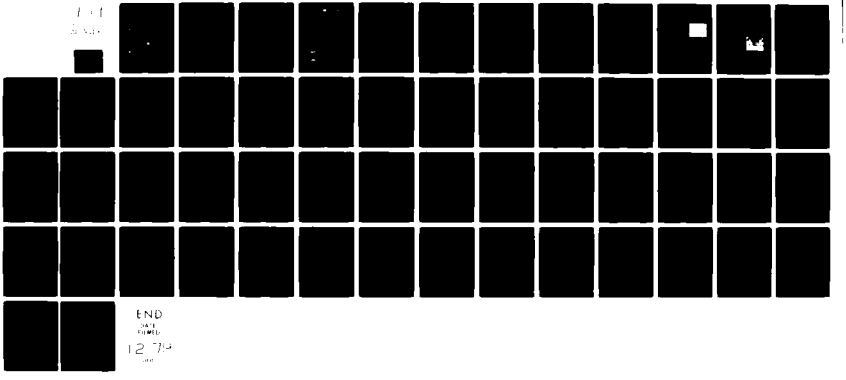

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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scientific staffs of the United States Air Force's Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

EUROPEAN SCIENTIFIC NOTES OFFICE OF NAVAL RESEARCH LONDON

I. Kaufman, R.E. Machol and Victoria S. Hewitson

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NEWS & NOTES

ONRL REPORTS

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AVIATION

THE COCKPIT OF THE FUTURE

The cockpit of a modern airliner is an extraordinary complex of instruments, switches, displays, and controls. To us laymen it is merely impressive, but to the beginning pilot and/or flight engineer who is charged with the responsibility of supervising every last one of these displays and operating every last one of these controls, it represents a frightening and almost impossible task. To the repairman, it represents a terrible problem. It is not as bad as it used to be, when many of the instruments were driven by a cable that rotated a dial, or by a tube which carried suction or pressure, and the control devices operated bell-cranks or wires that ran over pulleys through the aircraft and eventually mechanically actuated some device. Now the controls are generally hydraulic and the instruments actuated by electrical signals; this still leads to an impenetrable maze of wires and hydraulic tubes behind the panel. To the designer it represents a frustrating task, for the pilot of the future needs far more information than he now has, such as the locations of neighboring aircraft and sensors for new devices such as the MLS (microwave landing system); and there simply is no place to put these newer displays and controls, since the cockpit is now covered by them, including the walls and ceilings. To the systems engineer it represents a costly and unreliable system—note that hydraulic controls were a principal cause of the DC-10 crash at Chicago.

What is going to happen is reasonably clear: the controls will be separated from the displays; the displays will be electronic solid-state devices, and they will not be dedicated to specific uses—that is, a particular device can show one kind of information at one time and a different kind at another time. Thus, the cockpit will have a few CRTs (cathode-ray tubes), a panel of buttons and switches by which the pilot can select the display he wants, and a set of control switches and buttons not too dissimilar from the present ones except that they are separated from the displays. Behind these panels there will be only wires, because everything will be electrical rather than electromechanical or mechanical or hydraulic. And since everything will be electronic, mostly solid-state, the reliability will be high.

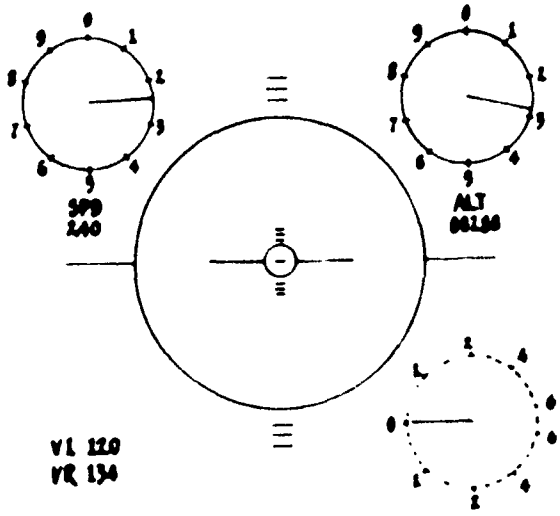
The next generation of aircraft, the Boeing "5" and "7", the Douglas plane still referred to as the DC-x and the European Airbus A-300 series, will make some moves in the above directions. For example, the B-767 will have a CRT for attitude and another for navigation; the former will be dedicated (i.e., inflexible) while the latter will permit some mode changes. It is the next generation of aircraft, those to be built in the 1990s and operated in the 21st century, that will have the all-electronic cockpit. Meanwhile, the only such cockpit in the world is in a simulator at the British Aerospace Corporation, UK's nationalized manufacturer of aircraft, in Weybridge, Surrey, a 30-minute train ride west of Waterloo Station in London.

This simulator does not move, and there is no external vision system. Some other simulators, especially those utilized for training, have both of these aspects of verisimilitude to an extraordinary degree. For example, a simulator at NASA's Ames Research Center in Moffett Field, California, has six degrees of freedom (up-down, back-front, left-right, pitch, yaw, and roll), and possible lateral motion of over 100 ft, to reproduce motion sensations realistically, and a three-degree color presentation on the windscreen of the terrain in remarkable detail, all under computer control so that when the pilot pushes on the stick, the cockpit starts turning, as does the presentation on the windscreen. While such verisimilitude is desirable, it is not essential in the Weybridge simulator, which is not used for training, and it would have increased the cost enormously. Nonetheless, about £1.5 million have already been expended on it, so one could assume that it is not a trivial device, and indeed it is not.

The basic cockpit is that of a super VC-10, a British Aerospace airplane comparable to the Boeing 707, which is operated by a crew of three, namely a pilot, a copilot, and a

flight engineer, with space behind for 3 observers. The size and shape of the cockpit and the positions of the seats and the controls (stick and rudder pedals) are identical to those of the datum aircraft. But there the resemblance ends. Below the windscreen in front of the pilots is a clean, bare panel in which are imbedded seven CRTs and a few warning lights. To the left of the left seat and to the right of the right seat are large sets of buttons for controlling these displays. And in the ceiling are all the buttons and switches. Thus, all data are in front, all aircraft controls are above, and the computer controls are on the side. And while the switches are above, the pilot does not have to look up to find their status; that information—which switches are on, which valves are open, which devices are under manual (as distinguished from automatic) control, and the like—is also displayed on the CRTs.

Not only are the data (on the displays in front) divorced from the controls (above), but the flight information displays are completely separate from the engine and system displays. The flight information displays consist primarily of an EADI (electronic attitude display indicator) and an EHSI (electronic horizontal situation indicator). The two CRTs on the left are used to display these to the pilot, and the two on the right show the identical information to the copilot. The displays are flexible, and either CRT can be used for either display. They tend to simulate existing displays simply to make them more acceptable to pilots used to the conventional types. For example, the EADI, indicated in the figure, shows on the center of the scope a picture very similar to the "artificial horizon" on currently operational airliners, which is a gyroscope-driven electromagnetic display of a conventional symbol for an airplane that rises or falls above a reference line, or tips left or right, as the airplane does the corresponding maneuver. But here, on the same display, are shown other pieces of information: in the upper left, airspeed, both digitally and as representation of conventional speedometer; in the upper right the altitude, also both digitally and conventionally; in the lower right the vertical speed ("rate of climb"); in the lower left some reference speeds, and other information not shown on our illustration.



The EHSI has several modes available. One shows a conventional compass rose in the center surrounded by information on radio frequencies and the like; in the other, the compass rose in the center is replaced by a detailed map which may show terrain features, navigation aids, airfields, weather, location of other aircraft, or whatever other information is available. The scale of this map can be changed at the touch of a finger to show a large surrounding region or to zoom in with great detail on whatever is very close.

One of the central CRTs is normally used for the engine display. For each of the engines, the display shows certain data in digital and analog form, and in appropriate cases shows both the commanded and achieved values, by means of a "bug" that moves along the scale.

The use of the computer-driven CRTs allows for some fascinating possibilities. For example, there are innumerable "check lists" that the aircrew must follow. Thus, the landing check list has "wheels down and locked," "flaps down," and so forth. Normally these lists are written on the "kneepad," a pad held in the hand or on the knee of the copilot or flight engineer, and he reads it aloud as the pilot confirms that each item has been appropriately performed (or if the flight engineer reads it, both pilot and copilot confirm). Here the check list appears on a CRT, together with an electronic

cursor. As the pilot checks off that he has performed the appropriate act, he presses a button that erases that item and moves the cursor down to the next one. If he wishes to skip an item and go on with the rest of the list, he may do so, the cursor moving on down, but the item not being erased. If he then gets to the bottom of the list and wants to go on to the next "page," he cannot do so until he has gone back to the skipped item and checked it off.

In case of emergency, the presentation of such check lists can be invaluable. For example, there is an "engine on fire" check list, which can be brought up easily. (In fact, although this is not done in the present simulator, it could be brought up automatically when an instrument indicated that there is such a fire.) Appropriate pages from an entire trouble-shooting book can be presented, as desired by the pilot or copilot or as seems desirable under computer control. The days of Hal (in *2001: A Space Odyssey*, 1968) are well nigh upon us!

As stated, this simulator is not used for training, but for engineering design and assessment purposes. The general concept of the CRT-instrumented cockpit had to be checked out—the acceptability of CRTs, eye fatigue, and the like—and more importantly, various design considerations and trade-offs have had to be studied. What are optimal display formats and character fonts? How should night lighting be arranged? Where should the CRTs be located and how large should they be? What information should be displayed where? How much redundancy is desirable? What is the reliability of such a system? How do people react to it in time of stress, and how can it be improved in this regard?

The tool for answering these and similar questions is full-mission simulation under conditions of considerable verisimilitude. The aircrew is briefed on a flight, usually London to Paris or Paris to London, because those computer programs have been worked out in detail, although the simulator is general-purpose and could be used for flights anywhere. The crew usually includes a project pilot, who works for British Aerospace, and an assessment pilot, who comes from the outside—the airlines, the military, or whatever. Typically such a pilot will be detailed to the simulator for these experiments for a period of a week, during which he will "fly" on the simulator for several hours each day.

The preflight briefing will tell the pilot everything about the flight, except for the faults that are going to occur and deviations from the original flight plan that will be given to him by ATC (air traffic control) while he is in flight. He will then go through a complete simulation in real time; a flight from London to Paris will take about an hour, including taxi to take off and taxi to the hangar after landing. During all this time he is in communication with the "tower," the "ATC," and various other people on the radio, and his instruments give readings corresponding to the actions that he has taken—in terms of position, attitude, speed, and the like. Thus, if he turns his wheel to the left, his EADI will indicate the new attitude of his aircraft; his EHSI will indicate the new heading; and the navigation data will subsequently show that he has traveled on this new heading.

In most flights, something unexpected happens—all preprogrammed according to a detailed scenario, but unbeknownst to the flight crew. This may be an engine on fire, the failure of a fuel pump, the sticking of a valve. Of interest may be how long it takes the crew to discover the failure, and how they react after they have discovered it. This research may be devoted to engineering questions—how should lights and/or sounds for warning purposes be designed?—or to human factors questions (which in England are called "ergonomics" questions), such as the ability of the aircrew to receive and process information under conditions of stress.

Because the UK is in the consortium that manufactures the A-300 Airbus and its successors beginning with the A-310, some of the results from this simulator have already been incorporated in the newest models. The major results, however, await the design of the next generation of aircraft, which will undoubtedly have this type of cockpit.

In a proper mix of simulator technologies, a facility of this type, with its multifaceted capabilities, is an extremely powerful tool for the design of improved aircraft. The US has been very successful in building and selling commercial aircraft to the rest of the world (thus keeping our balance of pay-

ments deficit from becoming catastrophic) for many reasons, chief among which is that we have had the technological design tools, such as wind tunnels, that enabled us to build better aircraft. This author concurs with the position of British Aerospace that a simulator such as this one is an essential element for any nation that wishes to compete in aircraft production in the future. (Robert E. Machol)

EARTH SCIENCES

THE OCEANOGRAPHY PROGRAM AT THE ROYAL NETHERLANDS METEOROLOGICAL INSTITUTE

The largest group of physical oceanographers in the Netherlands is in the Division of Oceanography of the Koninklijk Nederlands Meteorologisch Instituut (KNMI). Dr. R. Dorrestein, the director of the Division, is also Professor of Oceanography at the Univ. of Utrecht. The Institute is located in beautiful Klooster (Cloister) Park in DeBilt, in the outskirts of the city of Utrecht. The park is the former site of a medieval cloister. The Institute is surrounded on two sides by stately old houses and gardens shaded by tremendous trees and separated by winding, duck-filled canals.

KNMI is the center for weather forecasting and research for the whole country. However, it also has a long tradition in maritime meteorology and oceanography going back 125 years when, in 1854, the Dutch followed the suggestions of US Navy Hydrographer Matthew Fontaine Maury and began to use their extensive fleet of merchant vessels to collect wind and current data. This work continues to this day. Until 20 years ago the Institute enjoyed worldwide fame for publishing marine climatological atlases. Since then, however, the US and other countries have taken over the production of the atlases.

There is no formal teaching at the Institute. Students can, however, earn degrees in meteorology or physical oceanography at the Univ. of Utrecht and do their thesis research at the Institute.

The Dutch weather ship *Cumulus*, which spends half its time on station at lat. 66°N and long. 2°E between Norway and the Faroe Islands, is at times used by the Institute for oceanographic and marine meteorological research. In addition, 30% of the available ship time for the new 3000-ton naval oceanographic survey ship, *Tydeman*, is alloted to civilian oceanography, of which KNMI utilizes about one third.

There are eleven oceanographers at KNMI, with 25 supporting personnel in the Division. In addition, the Division is serviced by a large computer group and a well-equipped and staffed instrument shop.

The policy of the Division is to select research that is of mutual interest to oceanography and meteorology, so that it can take advantage of meteorological research being carried out in the same building and have direct feedback from it. The Division is dedicated to practical applied research that can be used to improve the services of KNMI in weather forecasting as well as forecasting storm surges, residual currents, and sea and swell in the shallow North Sea.

The development of the Division of Oceanography was stimulated by the disastrous storm surge of 1953 that broke through the dikes and flooded the polders in a number of places. Later stimulation came from the discovery of gas and oil in the North Sea. KNMI now is one of the few operational institutions that combine oceanography and meteorology.

Dr. E. Bouws is studying the wind and wave climatology of the very shallow Netherlands Sector of the North Sea which is located to the north and west of the Netherlands. The goal is to determine the maximum wave heights that will affect gas well platforms. From a study of wind and wave data from past storms he has found evidence that the shallow bottom (30 m) decreases the expected maximum wave heights with a probability of 0.001% (4.4 hours in 50 years) by about 10% from 14.8 m to 13.5 m.

Bouws has found that under extreme wind conditions the contribution of swell entering the study area from the northern North Sea is of minor importance owing to the shallow bottom topography of the area from the Dogger Bank south. Interaction with bottom

topography appears to decrease the swell height. This implies a strong correlation between local wind and extreme wave heights. It seems that bottom depth primarily governs the probability of extreme wave heights, without causing a clear distortion of the spectral shape from that found in deep water during the German JONSWAP wave studies (See ONRL C-8-75 by F.N. Spiess and ESN 29-2:83). One interesting result of the studies was the fact that with relatively high waves in shallow water, the significant wave height (average height of the highest 1/3 of the waves) is strongly correlated to the mean wave period. It is concluded that wave spectrum for extreme wind conditions can be inferred from wave height only.

During the first stage of the development of an air-sea interaction program at KNMI it was realized that all commercially available wind sensors have their shortcomings when used near the sea surface in the spray zone. Dr. H.A. Oost was given the task of designing and constructing a fast responding 3-D anemometer of fairly small size that would be resistant to spray, salt accretion, rain, and wave action. Cup, sonic, and hot wire anemometers are all vulnerable to one or more of the above. The principle of the differential manometer was selected. The main problem to be solved was to design a system of orifices in 3-D pressure heads that would eliminate most of the directional dynamic effects of the turbulent wind over the water surface.

Through a series of theoretical studies followed by reiterative trial and error designs combined with wind tunnel studies, the pressure head design shown in Figure 1 was developed. (Persons interested in the design features may write to Oost, who has prepared a packet to send to interested persons.) The device is internally pressurized so that air is leaking out of all the holes. This makes it self cleaning and prevents any sea water or rain from entering the holes in the sensor head. Fluctuations in wind speed up to 20 Hz can be measured and recorded by the complete instrument package.

The instrument is designed to be placed in a fixed position on a boom extending from a platform or tower in the sea. The platform selected for field testing is Meetpost Noordwyk, a former "pirate" television station platform five miles off shore, now used for testing instruments. This will be also used as a radar platform during MARSEN (an international marine remote sensing experiment) to obtain ground truth on the surface waves for comparison with wave data to be obtained by satellite.

Initially the wave heights will be determined with a resistance wire. The first program will be to determine the Reynolds stresses under various conditions including measurements of the increase in stress when waves are breaking. It is also planned to monitor the relationship between the phase of the waves and the wind structure over them.

Mr. C.G. Korevaar is a marine climatologist. The World Meteorological Organization has divided the oceans into eight regions and assigned the responsibilty for collecting and disseminating marine climatological data to various nations. The Netherlands (KNMI) was assigned the Mediterranean Sea and the southern half of the Indian Ocean. Yearly summaries are published for selected areas giving monthly reports of water surface temperatures, air temperatures, wind data, dew point temperature, visibility, weather phenomena, and surface waves. All of the data come from ships selected from the merchant marine. The program began in 1961 and is up-to-date through

1968. It is scheduled to continue until 1990 when a large atlas covering all of the oceans is scheduled to be published.

Koneraar is also working on improving the methods for ship routing, a service routinely carried out at KNMI for much of the Dutch merchant marine fleet sailing North Atlantic routes. The success of this endeavor is shown by the large number of ships voluntarily using the forecasts. Starting with 2 ships in 1960, the number had grown in 1976 to more than 200 from 20 companies. Each ship is given a two-day updated routing forecast everyday.

The results of using the forecasts are best in mid-winter and are better westbound than eastbound because of predominance of head seas on the westbound leg compared to the eastbound leg when following seas predominate. The best results are, on the average, in the European-Caribbean routes, although there are positive results on other routes. The savings in time are relatively small, usually a few hours at most. The big benefits come from smoother sailing, with less damage to ships, equipment, and cargo, and greater comfort and safety for crews and especially passengers. The results vary considerably from year to year. During summer they are marginal because of the usually prevailing good weather. However, on an average, a ship is better off being routed rather than following a great circle route.

As an offshoot of ship routing research, Korevaar has made a statistical study of storm occurrences in the North Atlantic. The number of easterly gales that occurred in the North Atlantic north of lat. 25°N have been estimated by using a selection of criteria involving the surface air pressure gradient for each day in the period 1881 to 1970. From this the dependence on the time of year as well as the distribution and variation over the years have been derived.

At higher latitudes between 50°N and 70°N the number of easterly gales per year appears to vary in a way that corresponds to a climatic fluctuation which has been related by H.C. Willett to the 80-90 year cycle in sun spot activity.

From five-year averages for each five degree band of latitude it was found that the number of storms per year increased with increasing latitude. However, there are great fluctuations at constant latitude, varying from 40 storms per year (1881-1885) to less than ten (1901-1905) to 70 (1956-1960) to 30 (1966-1970). The mean duration of storms at any given point was only 1.41 days, although the actual duration ranged from one to 10 days.

During the ocean wave study JONSWAP-'73, Oost made wind velocity measurements from one of the fixed masts (needles) near the tower PISA off the island of Sylt, Germany. He used a trivane anemometer called AEOLI that had been designed and built at KNMI. The anemometer consists of a propeller and toroidal vane that is free to turn and to tilt up to 45° from the vertical (fig. 2). It is similar to the US Gill trivane. It senses the three components of the wind. Data from this experiment are now being worked up by his collaborator, Mr. C. Krann. Prior to the wind study off Sylt, Krann had spent a good deal of time in evaluating the infrared thermometer as an airborne instrument to determine sea surface temperatures.

From 1972 to 1975 ten experimental flights (with a Barnes PRT-5 infrared radiation thermometer mounted on a DC3) were carried out in various seasons in a 100 km × 20 km area adjacent to the Netherlands.

He wrote a 100-page report on the problems of calibration, interpretation and the necessary corrections (KNMI W.R. 77-5). The report is written in Dutch

but has an extensive summary in English. Krann's basic conclusion was that with proper care the distribution of the sea surface ("skin") temperature over the coastal area can be reasonably well represented with a standard error of 0.4°C, in a digital grid with mesh size of 1.5 km.

One of the most important functions of KNMI is the forecasting of storm surges, i.e., higher than normal sea levels due to abnormal wind and air pressure distributions. Well-known surges are documented back to 1420 when 10,000 people perished and 72 villages were swept into the sea by a storm surge.

Dr. H. Timmerman is constantly working on the improvement of storm surge forecasting. In 1953 a storm surge raised the sea level 3.4 m above normal, and the sea flowed over the dikes in many places, causing a great deal of damage to the land and property. Afterwards, the main dikes were raised by an average of 1.7 m at a cost of twenty billion guilders ($150 million an inch).

Prior to the flooding in the 1953 storm surge, forecasts were based on statistical methods of forecasting the state of the water due to local winds within the North Sea. Since that time, the forecasts have been based more and more on physical relationships and the effects of surges external to the North Sea that come into the North Sea around the northern tip of Scotland and travel south to strike the Netherlands coast as long waves. At first the external surges were wholly attributed to wind stress over the shallow continental shelf west of Scotland. One of Timmerman's most important contributions to the improvement in storm surge forecasting was the discovery that air pressure gradients over the shallow water at the edge of the continental shelf west of Scotland are partially responsible for these external storm surges.

At the present time, 24-hour operational storm surge forecasts are made every six hours for six points along the Netherlands coast. The external surges can be seen in tidal gauge records as they come into and travel through the North Sea. They are first seen in tidal records at Wick near the northern tip of Scotland, which gives the Dutch a 10-hour advance warning of an external surge.

The most important tool of the forecasters is the surface pressure field that is generated by the KNMI four-layer model. From this, the external surge caused by pressure can be forecast directly. Then the surface wind distribution derived from the surface pressure field is used to forecast the external surge caused by wind stress and the set up caused by local wind stress within the North Sea.

Most of Timmerman's present efforts are centered on improving the accuracy of the forecasts for the surface pressure field over the North Sea and external surge development area west of Scotland.

Drs. P. Kruseman and G.V. Frangsma are primarily interested in the temperature distribution in the near surface layers of the ocean. Their main interest is an endeavor to model the near surface mixed layer and seasonal thermocline. The prime reason for this research is the influence of the sea temperature on the weather.

Frangsma and Kruseman, along with many other meteorologists and oceanographers, are convinced that one of the keys to improving long range weather prediction lies in a better understanding of the relationship between weather and sea surface temperature (SST) and the depth of the near-surface mixed layer. They believe that these parameters will provide a direct input into meteorological forecasting in the future.

The response time to cooling of the mixed layers is several months to half a year in winter. Any major or rapid temperature change in the mixed layer at a given location is due to advection. In summer the response time of the SST decreases to about five days; the feedback to the atmosphere and the whole mechanism of the heat exchange with the atmosphere is changed from that of winter.

KNMI has found that medium-range weather forecasting using analogue methods tends to be better in winter and summer than in spring, when the time of development of near-surface thermocline is very uncertain, and in fall at the time that autumnal overturning begins to erode the seasonal thermocline.

Ocean frontal zones are very important in winter, as their position may vary by as much as 50 km in relatively short times. One example under study at KNMI is the polar front between the northeastward North Atlantic Current

and southward flowing polar water in the Norwegian Sea near Ocean Weather Station Mike (66°N, 2°E). This front comes to the surface in winter, with a sharp temperature difference sloping down from the surface under the warm water. During the summer the front rises at the surface but shows up in CTD sections as an abrupt change in the depth of the mixed layer. It is much shallower in the warm water than in the cold. In their model of near surface temperature distribution and its changes, Brongsma and Kruseman are endeavoring to take into account the absorption of solar radiation down to a depth of 50 m.

Mr. H.A. Riepma is primarily interested in residual currents in the North Sea, with particular emphasis on the Southern North Sea to the west and north of the Netherlands. The studies are cooperative ones with various other agencies. Together with the Hydrographic Office and Ministry of Public Works he is working on practical problems, including the gathering of data needed in the study of dispersion of pollutants. He also took part in the Joint North Sea Data Acquisition Program (JONSDAP '76), involving the placement of 180 current meters by research workers from institutions in Belgium, Denmark, France, Germany, Norway, Sweden, and the UK with the purposes of determining: 1) the general pattern of average residual currents in the North Sea, 2) the in-out budget of waters of the North Sea, and 3) the physics of the various ways that residual currents are driven in the North Sea.

As a result of earlier work plus the JONSDAP '76 study, it was determined that meteorological conditions, especially wind stress, are the most important factors in causing the residual currents in the North Sea. This is particularly true whenever the winds are relatively strong and persistent. Interaction between the tides and irregular bottom topography can also cause residual currents, particularly in the shallower water and areas with rough topography. The latter residual components may be of a relative importance during periods of low winds or calms (EOM 33-7:296) and may vary spatially with variable bottom topography. During these periods relatively small components of the residual currents caused by external (oceanic) effects or density driven currents may assume importance.

In other experiments Riepma has found evidence of semi-persistent spatial variability in the form of eddies in residual currents in certain areas by using data from horizontal arrays of current meters. He believes that these "frozen eddies" or "frozen turbulences" are caused by interaction between certain features of the bottom topography and either wind-driven residual currents or possible tidal currents. Data from closely spaced (horizontally) current meters in shallow water sometimes show large persistent differences in residual currents. These differences are attributed to bottom topography.

Riepma intends to continue his studies of residual currents in the North Sea. So far the models he uses have been rather simple. The next step is to develop three-dimensional models in order to take into account the effects of stratification on the response of the North Sea to various driving forces. He believes that it may be useful to try to incorporate some of the findings of Brongsma and Kruseman on the changes in the basic near-surface thermocline. There are indications that stratification may also influence tidal as well as residual currents.

In summary, the Division of Oceanographs is making rapid progress on a large number of very practical applied problems that are important because much of the land behind the dykes is as much as 5 m below sea level. Wayne V. Burt

ENERGY

THE 15TH MEETING OF THE JOINT IAEA/UNESCO INTERNATIONAL LIAISON GROUP ON MHD ELECTRICAL POWER GENERATION

The 15th meeting of the Joint IAEA/UNESCO International Liaison Group on Magnetohydrodynamic Electrical Power Generation was held at UNESCO headquarters in Paris 25-27 April 1979. Attendance at the meeting included delegations from Australia, Austria, France, Hungry, Italy, Japan, the Netherlands, Poland, Sweden, UK, USA, and the USSR. The meeting was chaired by Prof. Dr. L.H. Th. Rietjens from the Tech. Univ. of Eindhoven, in the Netherlands. The scientific secretary of the meeting

was Dr. V. Chernyshev, the IAEA Scientific Secretary to the MHD Liaison Group in Vienna, Austria. The UNESCO secretariat comprised Mr. James I. McDivett, Director of the Division of Technological Research in Higher Education of UNESCO and Mr. V. Korsun of the Research in Engineering Sciences of UNESCO.

The first order of business was the selection of the site for the 7th International Conference on MHD. Three invitations had been received, from Australia, the US, and Italy. The Australian National Committee on Electrical Engineering of the Institution of Engineers proposed through representative Dr. I. H. Messerle that the conference be held in Sydney, Australia in 1980. The Italian proposal through Prof. F. Negrini that the conference be held in Bologna, Italy in the fall of 1980. However, it was decided that the conference be held in the United States at MIT, or Argonne, Ill., in the spring of 1981, as first proposed by Dr. M.J. Dept. of Energy. Subsequently, it was decided that a call for papers would be sent in September 1979, that the deadline for receipt of finished abstracts be 1 Jan 1980, that the meeting of the international program committee be held during February 1980, and that the deadline for full papers be in April 1980.

At this point, progress in MHD power conversion in the various countries was reviewed by the liaison group. Prof. S. I. Pischikov, of the High Temperature Institute, Moscow reported on progress in MHD energy conversion in the USSR. Various experiments in coal-fired channel and electrode materials were reviewed, but most exciting was the cooperative research with the US in which work with Russian magnets and American electrode walls as well as with Russian channels and American superconducting magnets were noted. The Russians indicated great satisfaction with the American superconducting magnet system. In addition, the Russians reported on joint work with Poland in the study of coal-fired MHD installations, with Bulgaria in the development of high-temperature air pre-heaters and the study of dust-laden flows in an MHD channel, with Hungary in the study of diagnostics of plasma in an MHD channel, and with Romania in the study of the properties of flows of a plasma of coal combustion products. Furthermore, joint Russian-Indian work was continued in 1978 in the development of an experimental coal-fired Indian-MHD installation. At the present time the Russians do not seem to place great value on oxygen enrichment of combustion air.

In reviewing the American program, Mr. A.L. Liccardi (DOE Dept. of Energy) indicated a design philosophy strongly favoring oxygen enrichment. The main thrust of the program is leading to the development of coal-fired MHD power generation in 500-1000 MW units, and it seemed to this observer that there were few doubts that this objective would be obtained. At the present time there is a large program in the development of subsystems of the MHD power train in various centers around the country. Also, the Netherlands is cooperating with the US in a blow-down channel facility at the Technical Univ. of Eindhoven.

The Japanese reported through Prof. Yasutomo Ozawa of the Dept. of Nuclear Engineering and Science at the Univ. of Hokkaido, on the latest research efforts in MHD power generation in Japan. He said that the Mark-V generator, which consists of the minimum necessary components required for testing of the generating channel, will be advanced to continuous running for approximately 200 hours at 100-kW output. The Mark-8, which is an experimental generator for continuous system operation, is composed of MHD power components including a superconducting magnet.

The Hungarians via Dr. K. Szendy (Design Inst. for Power Plants in Networks, Budapest) reported on their efforts in MHD plasma diagnostics, including holographic plasma investigations in the Russian U-25 plant. Reports of Yugoslavian activity in the study of various MHD components including superconducting magnets, heat exchangers, and channels were received along with the news that two generators are in the planning stage. However, the report pointed out that MHD is considered more for industrial processing applications than power conversion. In the future it is expected that emphasis will be placed on using coal as a fuel.

The Italians, reporting through Prof. F. Negrini, disclosed their plans for conducting MHD experiments involving diagnostics. Also it was

announced that the Italians will be cooperating with Eindhoven on MHD shock tube experiments. Other studies involving solar MHD were indicated. Although studies involving liquid metal and two-phase MHD was largely discounted by the major researchers in MHD power conversion, it was disclosed that there is interest in solar MHD power at the Ben Gurion Univ. of the Negev in Israel. Prof. Herman Brannover of that University is conducting systems studies that seem to indicate certain advantages along with economic competitiveness for solar MHD power as compared to more conventional forms of solar energy conversion. It was also reported that MHD power generation activities in France and in Germany are presently in limbo.

Though the Australians did not win in the competition to hold the 7th International Conference on MHD Electrical Power Generation, it was indicated that the Liaison Group would react favorably to an Australian proposal to hold a specialists' meeting on open-cycle coal-fired MHD in Sydney, Australia in September 1981.

Dr. G. Rudins of the DS Dept. of Energy was nominated as an alternate member of the MHD Liaison Group and chairman of the International Program Committee for the next conference. Support for the forthcoming international conference from IAEA and UNESCO is being sought. (Martin Jessen

ENGINEERING

THE THERMAL SCIENCES AT THE ECOLE POLYTECHNIC FEDERALE LAUSANNE (EPFL)

The Thermal Sciences Division at the Swiss Federal Institute of Technology in Lausanne (EPFL) consist of the Institute of Thermodynamics, the Institute of Applied Thermodynamics, and the Institute of Aerodynamics. The scope of the activities of the Division include thermodynamics, mechanics of fluids, thermal machines, chemical processes, and energetics. The Inst. of Thermodynamics is under the direction of Prof. L. Borel; the Inst. of Applied Thermodynamics is directed by Prof. Dr. P. Suter. The Chair of the Inst. of Aerodynamics is at present vacant owing to the untimely death of Prof. S. Gouda. My host during a visit to EPFL was Dr. Rene Platt of the Inst. of Aerodynamics.

EPFL and ETHZ (Eidgenössische Technische Hochschule, Zürich) constitute the Swiss Federal Institute of Technology. These two universities were discussed in a recent article by G. Wyman (see ESN 33(7-2)51).

At the Inst. of Aerodynamics I saw work by Dr. B.P. Truong on jet mixing, in which the far field from a 1-cm-dia. round jet of Reynolds number 10,000 was being studied by laser Doppler velocimeter techniques in an Eiffel type tunnel of contraction ratio 1:10 with a 25 cm × 25 cm cross section test section and a test section velocity of 10 m/sec. Turbulent bursting in boundary layers was also being studied on a 1.8 m long flat plate in the tunnel. In a supersonic wind tunnel with a test section cross section of 4 cm × 10 cm and a Mach number of 1.8 at a stagnation pressure of 7 bars, the trajectory of particles suspended in the flow were plotted after going through an oblique shock wave. The particle scale was of the order of 1 μm and consisted of oil and latex droplets. The wind tunnel discharged to the atmosphere. Another wind tunnel set up for studying flow-induced oscillations had a test section 70 cm wide × 50 cm high and velocities up to 35 m/sec. The tunnel had a 6-component strain gauge test mounting.

A project of some interest was a hot water driven supersonic blow down tunnel. The tunnel had a nozzle designed for Mach 4 operation in the test section, but only Mach 2.6 has been thus far achieved. A large boiler in which water is heated to 250°C at 55 bars is connected to the primary nozzle of an ejector which serves to move air out of the test section of the wind tunnel. In this manner, runs of the order of 1 minute in length are obtainable in a device that is far cheaper than the usual type of wind tunnel. In another subsonic wind tunnel designed for studying the aerodynamics of buildings and structures, the atmospheric boundary layer can be modeled. This tunnel has a test section of dimensions 70 cm in width, 100 cm in height and 10 m in length in which velocities up to 15 m/sec are attainable.

In the Institute of Thermodynamics, Engineer Rudolph Dobler is studying combustion processes in gas turbine combustion chambers. In this facility liquid hydrocarbon fuel is being burned in air at a pressure of 1.5 bars. The study is particularly concerned with the formation of the various nitrogen oxides. However, there did not seem to be any means of changing the geometry of the combustion chamber or the swirl ratio of the flow. In a neighboring facility a total energy module was under test for the FIAT corporation. This module consists of a 1-liter automotive engine connected to a 22-kW generator from which all heat is recovered. The fuel used is methane produced from animal waste. The unit is intended to provide energy on farms.

In the Institute of Applied Thermodynamics Mr. Thorsten Fransson is studying transonic flow in turbomachinery cascades. The transonic tunnel test section is 180 mm high by 100 mm wide and has a pressure of 1 atm. The Mach number is variable from 0.3 to 1.6. Purely two-dimensional flow can be set up by sealing the ends of the plates against the sides of the wind tunnel, but studies with blades tip clearance can also be carried out.

The energy absorption in a gas filled with particles (bromine containing graphite) is being studied in connection with possible application as an energy absorbing medium for a heliostat. The work is being performed by Ingr. Knedi Kriese. Kriese is also studying the performance of an evacuated flat plate solar collector, the emptying and filling of a stratified hot water storage tank while preserving the stratification, and the setting up of a multistage flash desalinization process that could operate with variable energy inputs such as solar energy. To function successfully such a process must prevent the overflow of sea water so that it doesn't contaminate freshwater in the freshwater collectors and also the blow-by of steam to the next stage of the flash process.

The foregoing plus a number of interesting student exercises including shock tube and one-dimensional flow studies made me feel that a worthwhile program is being developed at the IPIL. (Martin Lessen)

FLUID DYNAMICS

L'INSTITUT DE MECANIQUE DES FLUIDS IN TOULOUSE

The Institut de Mécanique des Fluides (IMF) constitutes the Department of Hydraulics of the Ecole Nationale Supérieure de Electrotechnique, d'Electronique d'Informatique et d'Hydraulique de Toulouse, which in turn constitutes one of the three Ecoles Nationales Supérieures of the Institut National Polytechnique de Toulouse. IMF is associated with CNRS (French National Science Foundation); its director is Prof. J. Nougaro. The personnel associated with this Institute number 114 and consist of 11 professors and directors, 24 research associates and research assistants, 14 research engineers, 46 technicians and administrators and 19 student researchers.

In a laboratory devoted to the study of transport in porous media, Dr. Serge Bories described the three facets of the research program as studies of single-phase natural convection, two-phase thermomigration, and multi-phase isothermal flow.

In the single-phase natural convection transport studies, a Benard apparatus with a layer 5 cm thick and 50 cm x 70 cm in area is being used to study natural convection of water through a uniform sand bed. The convection is, of course, driven by a temperature difference below and above the bed. Natural convection with the bed in a horizontal position and inclined to the horizontal have been studied. It was found, for instance, that with the bed inclined to the horizontal, at first a single convective roll with its axis perpendicular to the direction of inclination filled the entire bed; the flow direction for this single cell was in an uphill and downhill direction. When the convection was driven with a higher temperature difference, however, another convective mode appeared in which a number of rolls were aligned with their axes in an uphill/downhill

direction. Single-phase thermally driven natural convection was also studied in tall cylinders in which the aspect ratio of the cylinder and boundary conditions on the sides of the cylinder were varied.

In the two-phase thermomigration research program, the problem of autovaporization of a high enthalpy geothermal flow entering regions of low pressure is being studied. This research is of importance in the area of geothermal energy extraction where hot ground water seeps into lower pressure areas close to the surface and and flashes into steam.

In the program of isothermal multiphase flow through porous media, in which the flow of water and oil mixtures is being investigated, it was found that when water is used to displace oil from a porous medium, the front between the oil and water is not at all distinct, but rather smeared. Effects such as the preferential wetting of a medium by one or the other phase and capillary imbibations are being evaluated with respect to their effect on oil recovery. Such research in transport in porous media at IMF is supported in large part by the Institut Français du Pétrole.

In a laboratory devoted to pollution studies, under the direction of Dr. M. Alquier, I saw some interesting experiments involving the transport of solid particles by fluids. In one of these experiments, the transport of solid particles by fluids at a sudden enlargement was being pursued, and one could note two different scales of the circulating flow currents. The first of these scales is associated with the sudden enlargement; the second with the wave breaking of the shearing layer at the edge of the jet issuing from the small opening into the large chamber. In this study the trajectory of a single particle was studied by data reduction from recorded TV pictures; thus the observations of many particles yielded statistical transport data. The motion of particulate matter in swirl tanks is also under study, in an attempt to see how the design of such tanks could be improved.

Rheological studies involving non-Newtonian flows of long chain polymers in solution are being conducted in a Poiseuille flow apparatus, and in cone and plate rheometers. In this work steady or pulsed pressure-driven flows through a pipe are carried out to evaluate the effect of polymer suspensions of herboxyl-methyl-cellulose on the flow properties and also to evaluate the effect of aging on the polymer. A study is also being conducted on the properties of sinovial fluid from the joints of animals, as well as aging effects on the properties of this fluid. As far as I could note, the rheological work is purely experimental, and no microscopic basis for macroscopic properties is being investigated.

There is an interesting program in turbulent flow research at the IMF under the direction of Dr. H. Ha Minh. This involves experimental work on turbulent jets and wakes, the application of turbulent closure schemes to "prediction" of the average flow, and actual numerical interaction of the Navier-Stokes equations to give some detail of the turbulent characteristics of a flow. Experimental work on a wake behind a cylinder is being carried out in a wind tunnel of cross-section 60 cm × 70 cm, 160 cm in length, with a maximum flow velocity capability of 50 m/sec. This is an extremely low-turbulence level tunnel such that the level of turbulence is less than the noise involved in the hot-wire diagnostic equipment. The cylinder producing the wake is 4 cm in diameter. The data from the wake of the cylinder compare very well indeed with the direct integration of the Navier-Stokes equations but does not seem to compare so well with any of the various turbulence closure models thus far proposed.

In another apparatus the turbulent diffusion of carbon dioxide in a jet issuing from the end of a long pipe is being studied. The pipe is oriented vertically, and the jet issues downwards from the bottom of the pipe. The Reynold's number of the fully developed turbulent flow in the pipe is 54,000. Curiously, the jet emerging from the pipe begins to spread immediately at the same angle as that of the far-field of the jet. The average velocity distribution in the pipe seems to predispose the flow at the exit to an azimuthally periodic disturbance of the same form as that of the far-field velocity distribution. When the jet is turned off, the carbon dioxide spills out of the bottom of the pipe in much the same way

that a buoyantly driven plume emerges from a chimney. The mixing characteristics of this carbon dioxide plume are therefore different from those cases in which buoyancy effects do not predominate. Attempts at modelling these flows using Launder and k-ε closure schemes have been carried out by M. Patrick Chassaing.

Numerical integration of the complete Navier-Stokes equations for recirculating flows in sudden enlargements, rearward facing steps, and wakes have been carried out by M. Gines Martinez for a variety of initial conditions. In the case of the wake, a fundamental oscillation dominated the flow picture.

The IMF is pursuing a meaningful program of research with very capable personnel, excellent equipment, and extensive facilities. The researchers are very much aware of the latest developments in their respective fields and are contributing actively to them. (Martin Lessen)

THE INSTITUT DE MECANIQUE STATISTIQUE DE LA TURBULENCE (IMST) IN MARSEILLE

The following is a report of a visit to the Institut de Mécanique Statistique de la Turbulence of the University of Aix-Marseille, one of the well-known research centers in France, that has been concerned with statistical turbulence for a number of years. Its director, Prof. A. Favre, who has strongly influenced the development of the Institute, has recently become a member of the French Academy of Sciences.

The details of my visit were organized by Dr. Louis Fulachier, who is a Maître de Recherche of the CNRS—Centre National de la Recherche Scientifique, the French National Science Foundation. Fulachier grouped the work of the Institute under three categories: The first, the study of turbulence at low speeds with or without heat and/or mass transport, is under the direction of Dr. R. Dumas, who is also Associate Director of IMST and a Director of the CNRS. The second is the study of supersonic flows, under the direction of Dr. J. Gaviglio. The third program, involving the study of the interaction of the sea and the atmosphere, is under the direction of Dr. M. Coantic. It involves the use of a gigantic wind tunnel with a 40-m long test section providing an interface between a 2-m liter depth of water and a 3-m depth of wind moving over the water. This installation was discussed earlier by Barcilon (See *FM* 30-8:359).

An interesting problem being studied in the program of low speed turbulence with or without heat and/or mass transport is an experiment in an Eiffel-type subsonic wind tunnel with a 12-m long test section of 50 cm × 50 cm cross-sectional dimension that is provided with a plate for boundary layer studies on the bottom of the test section. Located 3-m from the leading edge of the boundary layer plate is a porous, sintered Alundum section that allows suction and heating to take place. In this manner the influence on the development of the turbulent boundary layer of a temperature step at the boundary and of suddenly applied suction is studied. The length of the porous plate in the tunnel is 2 m. The velocity outside the boundary layer in the wind tunnel is 12 m/sec. Data acquired in the tunnel are used to check a theory developed by Fulachier that purports to establish a spectral analogy between temperature and velocity fluctuations in turbulent flows. The difficulty, however, is that turbulent temperature transport and momentum transport involve somewhat different mechanisms in that temperature transport is limited to the wave breaking region of the turbulent flow whereas momentum transport takes place wherever Reynolds stresses exist.

In another study involving the turbulent mixing layer with an asymmetrical distribution of temperature, Fulachier found regions of negative production in the flow, an interpretation of which is that large scale eddys lose their energy to the average flow field in this situation. A similar situation can occur in hydrodynamic stability in the ordinary shearing layer at extremely high Reynolds numbers where viscous effects are negligible; in this case an eigen-disturbance with a wave number outside of the unstable range will be damped. Since the energy is not being dissipated by viscosity, it means that the resulting Reynolds stress increases the average flow velocity rather than retards it.

In another wind tunnel experiment, a 3-dimensional turbulent boundary

layer on a cylindrical body with blunt rounded ends is being studied. The flow direction is axial, and a 1-m-long section of the cylinder with its leading edge 1 1/2-m behind the roughened blunt nose of the 20-cm-diam. cylinder is rotated. The tangential velocity of the rotating section is approximately equal to the axial flow velocity of 12 m/sec over the cylinder. The thickness of the transverse boundary layer over the rotating portion of the cylinder is very thin, being only of the order of 0.05 mm in thickness. It would seem that this flow field on the rotating portion of the cylinder should exhibit a Goertler type instability and result in helical vortices over the rotating section.

An interesting experiment in turbulent flow in a pipe with a wavy wall, where the pipe diameter is 75 mm and the rotationally symmetric wall wave has a wavelength of 55 mm with an amplitude of 3 mm, is being conducted in the Reynolds number range of 30,000 to 140,000. The pipe length is 4 m; turbulence is established at the entrance to the pipe by means of a grid. The mean flow observed in the pipe is being compared with the numerical modeling of the turbulence with a closure scheme. Of course, the turbulence caused by the grid at the opening of the pipe has very little to do with the turbulence caused by the wavy wall and the resulting local and/or global instabilities. It is hard to see how a closure scheme with respective data matching parameters that would work for this experiment could apply to any other situation.

In the program of turbulence in supersonic flows, Gaviglio and coworkers have been studying supersonic wakes produced by flows transverse to a circular cylinder along with rotationally symmetric turbulent wake flow. Unfortunately, in these studies the size of the wind tunnel is such that it was not very much greater than the extent of the wake, and it could be that such large scale structures are suppressed by the geometry of the experiment. In the wake "near" fields, no large scale turbulent structures were reported; it was observed that transition seemed to occur gradually in the shearing layer. It could be that with greater time resolution (shorter exposures), the large scale turbulent structure of the shearing layers in the near wake would be revealed. (Martin Lessen)

MATERIALS

TWO CENTERS FOR OXIDE STUDIES IN PARIS

I recently visited two research centers in the Paris area whose primary interest is the study of oxides. Actually, neither of these has the word "oxides" in its title, and there is very little similarity between them except that they are both laboratories of CNRS (Centre National de la Recherche Scientifique—the French NSF): The Laboratoire de Physique des Materiaux, whose director is Prof. J. Philibert, and the Laboratoire d'Etude et de Syntheses des Microstructures, directed by Prof. Max Paulus. Philibert is associated with the Univ. of Paris XI (SUD), but his CNRS laboratory is located at a separate site, in Bellevue, 15 km west of central Paris. On the other hand, Paulus is a professor at the institution that is also the location of his laboratory, the Ecole Supérieure de Physique et Chimie Industrielles, (ESPCI), in the Left Bank university area of Paris. Both of these are full-fledged CNRS labs, as opposed to university labs with partial CNRS "CNRS Lab de ____ assoc de l'Univ. de ____." Interestingly, Philibert is on the board of directors of Paulus's lab, but not vice versa.

These two laboratories have quite different goals and approaches to the study of oxides, and in fact, the nature of the oxides being studied is basically different. Philibert's laboratory is interested primarily in the basic mechanisms of diffusion and plastic deformation in oxide single crystals. On the other hand, Paulus is concerned with the microstructure of multi-component aggregates of oxide powders, particularly as affected by processing. Philibert's laboratory at Bellevue has two main groups: plasticity (J. Castaing) and diffusion (C. Monty), with smaller groups for interfaces (A. Gervais) and thin films (A. Lozime and C. Sella). Most of the work to date has been conducted on model oxides such as NiO and Cu_2O, with some work also on molecular crystals, and it is intented to extend the work to other compounds, such as SiC. This last material has the pos-

sibility of application to "ceramic" gas turbines, of course, but the smell of applications is certainly not very noticeable in this lab. The laboratory has a total staff of about 17 scientists and about the same number of technicians, not counting the staffs of services shared in common with other laboratories at the Bellevue site, such as electron microscopy, x-ray diffraction, SIMS, photography, etc. By the way, these labs are situated in an elegant building that was formerly Isadora Duncan's "Hotel Particulaire," which, unfortunately, has had a disfiguring addition built in front of its original façade.

Castaing's main interest is mechanisms of plastic deformation, and oxide single crystals (most commonly Cu_2O, NiO, or Al_2O_3) are merely a means to study these phenomena. Plastic deformation is studied over a wide range of temperature, using high purity crystals doped with various impurities; for example, recent work has been conducted on Li-, Co-, and Mn-doped NiO. Specimen preparation and structural characterization is very demanding for this work because growth conditions have a profound effect on crystal perfection and so in turn on the deformation behavior. Berg-Barrett x-ray topography, etch pitting, transmission electron microscopy (TEM), and other techniques are used to characterize the structure of the crystals as-grown and after deformation. The basic information obtained includes the glide system(s) adapted by the crystal when it plastically deforms. The activation volume for plastic deformation is determined by deforming the crystals in compression in an Instron machine at several strain rates, or by stress relaxation tests. The data reveals all sorts of interesting phenomena, such as (in the case of Mn-doped NiO) serrated flow, and alloy softening, whose complete interpretation demands detailed studies. The laboratories for these studies are equipped with some very neat purpose-built machines for controlled deformation, with temperature and atmosphere control. The 1000-kV TEM at Chatillon and the synchrotron x-ray source at Orsay are used in the structural characterization phases of the work.

As in Castaing's group, Monty's group is engaged primarily in basic studies in well-known oxides such as Cu_2O and NiO, except that here the interest is diffusion. Several workers in Monty's group are devoting their time to the systematic study of oxygen self-diffusion and impurity diffusion in various oxides, including O in NiO (C. Dubois), O in Cu_2O (F. Perinet) and impurities in NiO (N. Tabet).

The secondary ion mass spectrometry (SIMS) technique of surface analysis has been adapted with a high level of precision to several aspects of these oxide diffusion studies. For example, in oxygen self-diffusion studies, SIMS analysis has been used to determine the depth concentration profiles of ^{18}O tracers in nickel oxide and copper oxide. Several methods of introducing the tracers are used, including heating in ^{18}O-rich atmospheres, and ion implantation. These SIMS studies have yielded quite different results for the self-diffusion coefficients and activation energies for diffusion than those obtained by classical atmospheric analysis (measurement of the amount of oxygen used from the atmosphere). The atmosphere measurements typically give much lower values for the activation energy (i.e., indicate easier diffusion than may actually be the case) than the SIMS results (2.6 eV atm. vs 5.6 eV SIMS for O in NiO).

Ion implantation, which usually is used to modify surface properties, has also been used by workers in Monty's group in unique experiments to deduce the stopping power of metals for charged particles traveling in them. In these experiments, oxygen ions have been impinged on copper single crystals oriented such that the ions enter along various channeling directions in the lattice (directions in which there are linear open spaces in which the impinged species can travel); the ions are slowed down energy losses occur owing to nuclear and electronic collisions. The ^{18}O concentration profiles are subsequently determined with the SIMS. The work is being extended from Cu to Al and Ni, which have the same crystal structure, to observe the stopping power as a function of electronic configuration.

Also within Monty's diffusion group, M. Brissaind is studying self-diffusion in single crystals of pivalic acid by means of radioactive tracer methods. In molecular solids of this sort, the mechanism of diffusion and

the point defects involved are still in question. For example, nuclear magnetic resonance (NMR) and tracer diffusion results disagree, supposedly as a result of variations in crystal perfection. Some studies are also conducted on metals, most notably surface diffusion work on nickel, where a grain boundary grooving method is used.

The laboratory equipment supporting the work in Monty's group is very impressive, including special annealing furnaces (for service up to 1800°C) with atmosphere control, ion implantation facilities, single-crystal growth and cutting, introduction of radioactive tracers, etc.

The activities of Paulus' laboratory are in direct contrast to Philibert's. Paulus does not want to study the ceramic crystals themselves, but rather aggregates of many crystals. He is particularly interested in characterizing these aggregates in terms of composition, crystal structure, and microstructure, especially as a function of processing history. There are strong applications-oriented reasons for interest in these features, since many technologically important physical and mechanical properties are quite sensitive to them, including electric, magnetic, and strength properties. For example, aggregates for magnetic applications, such as ferrites, are a major category of material studied.

Paulus' laboratory was originally one of three groups in a Laboratory of Magnetism and Solid State Physics headed by Prof. Guillautt and located at Bellevue. When Guillautt retired, these groups became three independent laboratories at Bellevue, and in 197[illegible] Paulus' lab moved to its present location at ESCPI in Paris. The group is somewhat smaller than Philibert's, with a total of about 20 scientists and technicians but with the advantage of greater student participation because of proximity to the Ecole.

One of the driving forces for existence of this group is the fact that microstructure is often neglected when considering factors that affect physical properties of materials (such as electrical resistivity and magnetic coercive force), whereas it is nearly always considered in relation to mechanical (strength) properties. This may be because of confusion between so-called "intrinsic" and "extrinsic" properties of materials. Many physical properties are "intrinsic," i.e., microstructure-insensitive, in that they depend only on the fundamental electronic structure, state of bonding, and crystal structure of the material; this includes such properties as melting temperature, elastic modulus, coefficient of thermal expansion, Curie temperature, etc. These properties are generally not sensitive to variations in microstructural parameters such as grain size, dislocation substructure, etc. On the other hand, "extrinsic," or microstructure-sensitive properties include such measures as yield strength, electrical resistivity, etc. However, the intrinsic, supposedly microstructure-insensitive properties are not always totally unaffected by microstructural changes, and one of the goals of Paulus' research is to delineate these effects.

The main microstructural parameters that are examined in the ceramic aggregates are grain size, porosity, compositional segregation, distribution of the different phases, strain, and magnetic microstructure (domains). As an example of the effect of such features on physical properties, compositional segregation at grain boundaries can create high electrical barriers and a factor of perhaps 10^3 difference in electrical resistivety.

One of the key factors in the development of the best properties (of any category) for an aggregate is to begin with fine-grained powder of the highest possible homogeneity. Such features as grain shape, surface oxidation (in the case of metals), absorbed gases, and impurities are important, but the main parameters are compositional and particle size homogeneity, because these strongly favor high densification during fabrication. There are a variety of alternative methods that may be used to produce the starting multiphase powder mixtures, including 1) high temperature reactions between metallic powders, oxides, and salts (the classical method, with porosities achieved after sintering are usually on the order of 15%), 2) reactions using molten salts, and 3) freeze drying.

The freeze-drying method is used exclusively in Paulus' laboratory, and a fine apparatus has been developed for doing this. The process is essentially the same as that used for preparing instant coffee, powdered milk, etc; that is, a homogeneous liquid solution of the appropriate salt composition is prepared, frozen rapidly to retain the homogeneity (for example, by spraying the liquid into liquid nitrogen), then sublimated to remove the water and leave a homogeneous powder mixture. Thermal treatments may then be applied to convert some compounds, e.g., sulfates to oxides, as required. Powder mixtures prepared in this way are able to achieve far better properties, mostly because of their state of consolidation and lower porosity, so that although freeze-drying may be more expensive than more conventional powder preparation methods, costs are saved in other areas (lower sintering temperatures are possible; hot pressing may be unnecessary owing to the lower porosity, etc.) and there are substantial properties improvements.

Among the many aspects of the work on these aggregates as a function of processing variables, one of the most fundamental is the modeling of the processes that control densification, grain growth, and segregation. Paulus seems to have the ideal knack of being able to couch the results of this work either in terms of basic physical laws or in terms of how to change the operational parameters in a practical situation. For example, he can tell you quite neatly about the cause and effect and the mechanism of the effect (on an atomistic level) of powder compositional heterogeneity, grain size heterogeneity, etc. The experiments are also carried out in such a way that useful practical information is obtained along with data of fundamental significance. As an example, the effect of time and temperature in various gaseous atmospheres (for instance, at various oxygen partial pressures) on aggregate microstructures is often studied, which yields insight to mechanisms of microstructural changes as well as ideas about appropriate sintering and annealing conditions.

The range of materials studied includes hard ferrites (e.g., $BaFe_{12}O_{19}$), soft ferrites (e.g., $MnZnFe_2O_4$), Al_2O_3 (substrates for integrated circuits), spinels (e.g., $MgAl_2O_4$, a material transparent in the visible and microwave regions and at the same time resistant to impact), ZnO, stabilized with yttrium and calcium, (for high temperature service), and corderite ($2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$, of interest because of its high thermal shock resistance). There also are studies of bone processes, and future work is intended on SiC.

The equipment in the laboratory includes complete facilities for all steps of powder and aggregate preparation (ball mills, presses, furnaces, etc.) as well as extensive facilities for physical and microstructural characterization, including differential thermal analysis, thermogravimetry, x-ray diffraction, optical and electron microscopy, electron microprobe analysis, magnetoscopy (to detect domains), microresistivity (resistivity across pairs of grains), and other techniques.

In summary, these are two fine laboratories working on quite different kinds of ceramic crystals in terms of their state of aggregation. Both groups are in hot pursuit of fundamental laws, in Philibert's case primarily for describing deformation and diffusion in simple oxide single crystals, in Paulus' case for describing the behavior of complex ceramic aggregates during sintering, pressing, etc. The latter work is tied much closer to practical applications than the former yet retains the same sort of basic science flavor. The Bellevue group tends to stay primarily on the atomistic-level in its analysis and characterization of behavior, whereas the other group understandably is often dealing with the macro-behavior of aggregates. (Jeff Perkins)

GENOA'S MARINI CORROSION LAB

Located in the midst of the bustling port area of Genoa, Italy, is an unobtrusive four-story building that houses (on the upper three floors) the Laboratorio per la Corrosione Marine dei Metalli (Laboratory for the Marine Corrosion of Metals). This is probably the world's only walk-up marine corrosion lab, and it turned out to be an amazingly diverse and thriving activity. The Laboratory has existed in this location for twenty

years, and is operated in patriarchal institute fashion as a laboratory of the Consiglio Nazionale delle Richerche (CNR, effectively the Italian NSF). The director is Dr. Emanuele D. Mor, who controls a close-knit group of about 30 workers (20 with baccalaureate or better) in a wide range of research projects. The impressive stack of recent publications (mostly in English) that was pressed on me indicates the activity of the group.

Since this is a marine corrosion laboratory, the corrosive environments considered are, of course, mainly sea waters (natural and synthetic) and salt solutions (3 1/2% NaCl solution). In spite of the proximity of the Laboratory to the Mediterranean sea, the more controllable man-made solutions are used more extensively. In addition to this seawater-related work, there is a bit of research on nonmarine corrosion, such as of mild steel in elevated temperature (up to 90°C) waters, related to corrosion problems in the cooling systems of iron and steel plants, and some work in acid solutions.

The seawater corrosion research emphasizes studies of the behavior of such materials as mild steel, copper, stainless steel, and zinc. Some of the particular aspects of the work include consideration of flow effects in the seawater corrosion of steels (with an apparatus operable in the range 0.2 m/sec to 2 m/sec available), cathodic protection, stress-corrosion cracking, pressure effects, crevice corrosion, deep ocean behavior of materials, and biological studies. There also are various facilities devoted to on-site testing in the sea, including a pump station for drawing natural seawater (then to be trucked to the laboratory and stored on the roof), and sleds for open ocean deployment of corrosion coupons. (This is typically done near Sardinia at a depth of about 100 m.)

Biological fouling and various microbiological phenomena are a special area of expertise of the staff, and the group working in this area has published very extensively, mostly in the Italian literature. The leader of the biological group, Giulio Relini, gave me a tour of the facilities devoted to these investigations. They include a special environmental chamber to reproduce natural conditions for the study of organisms such as algae and mussels, and a cinematic setup to study barnacle attachment via optical microscopy. There was also a huge freezer full of fouled samples waiting for analysis. The work of the biological group includes both corrosion and fouling studies, as well as some direct biological work unrelated to corrosion. In the latter category is some work on the effect of environmental pollution on biological life in the sea, precipitated by the breakup in the Gulf of Taranto of a ship full of lead additives for gasoline. The resident expertise is quite impressive in terms of biological characterization of various areas of the Mediterranean.

The nature of the corrosion research of this Laboratory generally involves close environmental control and electrochemical monitoring of reaction rates. Electrochemical techniques are used as tools rather than as a research end in themselves. The group is primarily interested in delineating environmental factors affecting corrosion rates in complex real-world-like solutions. Sophisticated electrochemical techniques such as rotating disc electrodes are used only to a very slight extent. Most of the experimental methods used evaluate average phenomena and microscopic observations and are not used to give fine-scale insight. However, one of the specialties of the Laboratory's work is identification of corrosion products, which is accomplished through a combination of x-ray diffraction and chemical analytical techniques. This also is done in order to help clarify details of the corrosion process in terms of critical variables. For example, recent work has led to the evaluation of corrosion products that form on copper, zinc, and steel in seawater. Some specialized spectrophotometric and polarographic techniques have been developed for these studies.

The effect of sulfides on corrosion of various materials (notably copper) in seawater has been a continuing theme of work, related to corrosion behavior in polluted seawater. For this work, membrane ion-selective electrodes have been adapted for the determination of sulfides in seawater. Also the effect of halogen-containing compounds on the corrosion of copper

in seawater has been under study recently. Other environmental chemical work has been on the action of inhibitors such as zinc gluconate, one of the first nontoxic agents, for mild steel in seawater.

As mentioned, one of the special apparatus is a high pressure cell. Recent work has considered the effect of hydrostatic pressure on the corrosion of copper in seawater. Research on this aspect is virtually impossible in the natural environment because of changes in other important variable, notably oxygen concentration and temperature, with depth. The lower corrosion rate of most metals in the deep ocean (with the exception of aluminum alloys) seems to be related mostly to the lower dissolved oxygen content and lower temperatures. Laboratory results, however, have been conflicting over the years, and the work at Genoa has sought to investigate the question under close control of oxygen, pH, and temperature, using biologically inert natural seawater and 3 1/2% NaCl solutions as the media. The initial results have shown that the corrosion rate of copper increases with pressure (for the constant values selected for the other variables) in both seawater and NaCl solutions. This is interpreted as being caused by accelerating effects of pressure on the cathodic reduction process. Another project is using electrochemical methods to look at crevice corrosion of stainless steel in seawater.

The extent of the work on corrosion in elevated temperature waters is not nearly as extensive as that at the National Physical Laboratory in the UK, described here recently (*ESN* 32-11:384), but the aims are similar. One difference is that at Genoa, corrosion rate data from weight change and electrochemical measurements is augmented by thorough analysis of surface films, a technique that is very useful in making interpretations of the corrosion processes. Another nonmarine environment that has been of interest to the group is acid solutions, and the investigations have included studies of inhibiting effects of certain agents. (for a report on other work in Italy on this subject, see *ESN* 33-8:328). Work in acid media has particularly investigated copper and steel.

In view of the current low level of research funding throughout Italy, the output of this Laboratory is notable both in quantity and quality. The level of sophistication in the experimental methods is not nearly as high as I have recently observed in other electrochemistry/corrosion laboratories in Italy and France (see *ESN* 33-8:328), but this is largely because of the complexity of the seawater electrolyte that is the primary environment being studied at Genoa. In fact, the acquired skill of the group in analysis of corrosion products derived in these environments is quite a notable accomplishment. The Genoa lab is nowhere near the scale of the extensive marine corrosion laboratories operated by International Nickel Company in North Carolina, but it is effective and productive for its size. It is working on a variety of significant corrosion problems, and as the only marine corrosion lab in Italy would seem to have a sound future.

MATERIALS RESEARCH IN BARCELONA AND SAN SEBASTIAN, SPAIN

A recent *ESN* article by Klick and Bernstein (*ESN* 32-11:377) suggested that materials research in Spain is centered around Madrid, with little evidence of any serious commitments toward developing similar programs in the regional universities. This is nearly true, but on a recent trip to Spain I discovered significant physical metallurgy research activities in both Barcelona and San Sebastian.

San Sebastian, in the Basque district in the extreme northwest corner of Spain, is the location of the engineering school of the University of Navarra. This University, which was discussed in these pages recently (*ESN* 33-8:312), is unique in that it is the only private Spanish university, having been established in 1952 by the organization Opus Dei. The main university center is in Pamplona, with about 7000 students, with other centers being in Barcelona (Business) and San Sebastian (Engineering).

There are several unique aspects of the private nature of the University. For example, the faculty are not subject to the tenure procedures described

here recently by Bernstein (*ESN* 32-3:97), so that younger members are able to carry on research in a fashion comparable to typical US universities, and promotions are based on both research and teaching accomplishments. Also, unlike most Spanish universities, most (80%) of the teaching staff at Navarra are full-time faculty members. The University also seems to have been exempt from the student agitation prevalent in most Spanish universities. That the students are content is not surprising to me in view of the outstanding organization of the academic programs, an example of what can be accomplished once the bureaucratic maze is escaped. It is probably relevant that the facade of the main building of the engineering school in downtown San Sebastian is the only one I have viewed in Spain, France or Italy that was not plastered with placards favoring various student causes.

In San Sebastian my visit concentrated on the "Centro de Investigaciones Tecnicos de Guipuzcoa" (center of technical Investigations; Guipuzcoa is the name of the region), part of the Escuela Tecnica Superior de Ingnieras Industriales, which is in turn a branch of the University of Navarra. This center is essentially the site of upper division and postgraduate university research in engineering. The director of the Center is Dr. M. Fuentes-Perez, who hosted me on my visit. Fuentes-Perez himself is a metallurgist and still heads up the research group in physical metallurgy which was the focus of my visit. The other sections of the Center are for electrical engineering, mechanical engineering, computing, and a small group in solid state physics. The research center has been strongly subsidized by a local savings bank, Casa de Ahoros Provincial de Guipuzcoa, which owns the very nice 9-year-old building and currently provides about 20% of the Center's operating budget (20% of 100,000,000 Pts). The bank provides these funds as indirect support for local industrial development.

The physical metallurgy group was orginally organized (about 10 years ago) by Dr. Jaime Faustmann, who established the practice of sending good people abroad to get PhDs. Faustmann himself earned his degree from Aachen, while Fuentes-Perez obtained a PhD from Sheffield, and most of his senior staff now have PhDs received at top universities in Britain and Europe. Research is carried out mostly by full-time research staff members and by postgraduate students, as there is currently a dearth of undergraduate metallurgy students. (This is true throughout Spain.) The physical metallurgy group at present includes five PhD staff members and a handful of graduate students.

The facilities for physical metallurgy research are quite nice, including fine electron microscopic and x-ray diffraction equipment and special mechanical apparatus, such as a hot torsion bench. There is also a purpose-built apparatus for directional transformation.

Within the physical metallurgy group several research themes are being pursued. The most prominent of these relates to deformation processes in metals, and some very nice microstructure-mechanical properties studies are being carried on.

Dr. J. Gil Sevillano, who just got his PhD in Leuven, working with Prof. J. Aernoudt (see *ESN* 33-4:148), has recently been developing experimental data and theoretical models for the strength of pearlite. Pearlite, an important microstructural constituent of steels, is a 2-phase lamellar mixture consisting of a ductile phase (ferrite) reinforced by about 12% (by volume) of a hard phase (cementite). The spacing of the lamellae vary with the cooling rate from high temperature, and the strength varies with this spacing. There is considerable controversy about deformation mechanisms and strengthening in this microstructure, which is technologically one of the most important in all alloys. The work carried out by Gil Sevillano is of such a nature that the strengthening and plastic anistropy of lamellar composites in general may be calculated in similar manner. He is also involved in studies on the deformation of single crystals, especially FCC metals such as aluminum, and the work is now turning to the very interesting problem of high-strain work hardening. Models for shear band formation in rolling and extrusion have been developed recently.

Fuentes-Perez's main interest recently has been directional transformation of eutectoid alloys, a

recent derivation of the directional solidification of eutectics. The technique used is quite similar: the specimen is undirectionally translated through a steep temperature gradient and is traversed by a macroscopically planar transformation front. If the appropriate experimental conditions are obtained, the single high temperature phase will leave behind a eutectoid transformation product that has an oriented lamellar structure. In the work at San Sebastian, once again we are talking about the austenite-to-pearlite transformation in steels, and so the work is complementary and closely allied to Gil Sevillano's work on deformation processes in these structures. In this work Fuentes-Perez has done both experimental and theoretical work, the latter aspect including consideration of crystallographic restrictions on growth. The main conditions to be met for development of well-aligned structures are: (a) a steep enough temperature gradient, to avoid both nucleation in front of the actual position of the planar transformation front and coalescence in back of it, and (b) a translation rate lower than the maximum possible growth rate of the lamellar eutectoid product. Another recent activity of Fuentes-Perez has been concerned with the development of modulated microstructures in iron-copper alloys. Again, this is work centered around experimental variables and delineation of crystallographic relationships, with considerable TEM orientation and submicrostructural data obtained in support.

While at the Center in San Sebastian, I also took the opportunity to visit with the small group in solid state physics. One of the researchers here, Francisco Sanz, using x-ray scattering techniques has recently initiated some very interesting structural studies of amorphous semiconductor materials. The first results have been obtained for amorphous Al_xGe_{1-x}.

In Barcelona I visited the Department of Metallurgy at the University of Barcelona, where my host was Dr. F. Climent, who directs the research group in physical metallurgy. The other interests in the Department are extractive metallurgy (Prof. Nunez, the department head), ferrous process metallurgy (Dr. A. Forn), and metallography (Dr. B. Fernandez). In toto, the research group in the metallurgy department consists of about 25 full and part-time researchers, including the four faculty members named. The metallurgy lab facilities are adequate but somewhat scattered around the campus.

The research group in physical metallurgy has current interests in three main areas: (1) "valve" metals such as Ti, Zr, and Ta ("valve" metals are those, which because of the characteristics of their surface films, will pass electrical current to a much greater extent in one direction than in the opposite direction, i.e., they have rectifying properties); (2) precipitation in Al and Cu alloys; (3) welding of austenitic stainless steels. Climent has also worked in such areas as single crystal growth, Hall effect, and textures. The work on valve metals is are intended to study metals other than Ta that have useful dielectric properties. The precipitation work includes development of aging curves and correlation with fractographic features. Based on earlier work in the areas of deformation textures, one of the main experimental techniques used in Clement's group is x-ray diffraction.

These two centers of physical metallurgy research activity, in San Sebastian and Barcelona, must be considered significant and legitimate, with valid contributions being made to the advancement of European science. Of course, the present Spanish output in physical metallurgy is almost negligible compared to many other European countries (e.g., Germany and France) in terms of quantity. But the quality is on the highest plane, and a fair proportion of the results are contributed to European (as opposed to only Spanish) journals. As suggested in the earlier ESN article by Klick and Bernstein, Madrid is certainly the center for metallurgy and solid state physics (and indeed most science, with the possible exception of medicine) in Spain. The materials research activities in Barcelona seem to be struggling for life along with the rest of technical activities at Spanish universities. However, the center in San Sebastian is in far better health than any at other Spanish universities I visited and is likely to continue to grow and have even more impact as time passes. (Jeff Perkins)

VERRE TEXTILE PLASTIQUES RENFORCES— REINFORCED PLASTICS

Glass fiber reinforced plastics have been with us for at least three decades, yet they are still considered new materials. Indeed, many new applications are being found for these composites and at an accelerating rate. The high performance continuous glass and carbon reinforced plastics (GRP and CFRP) are extensively used in aerospace construction and are finding their way into commercial aircraft. However, the high volume usage of reinforced plastics is in the short fiber glass reinforced plastics (GRP), which are rapidly replacing metals in automobiles, trucks, aircraft, household appliances, building, and small boat construction, to mention only a few applications. The reasons for the substitution of GRP for metals, wood, and masonary are varied. In automobiles GRP components represent a significant weight saving by weight reduction and the replacement of costly corrosive metals. In fact instances GRP are simply cheaper and more easily fabricated. The casing for household appliances, typewriters, sewing machines, etc., can be molded at high production rates with few rejects or scrap and with only minor finishing operations.

The state-of-the-art of GRP technology in the UK and Western Europe was revealed at the Reinforced Plastics Congress-1978 of the British Plastics Federation, held in Brighton 13-16 November 1978, and the 14th International Reinforced Plastics Conference at the Centre de Documentation de l'Industrie Textile et des Plastiques Renforcés, held in Paris on 28-31 March 1978. Both the British Plastics Federation and the Centre du Documentation are industry-sponsored organizations, and each organization selects its representative members. The purpose of the organizations is to promote the wider use of GRP, and the member companies include resin and reinforcement suppliers and GRP fabricators. The counterpart organization in the US is the Society of the Plastics Industry, (SPI) which holds the annual SPI Reinforced Plastics Conference.

Many of the papers at the Brighton and Paris meetings were unabashed sales promotion. This is not surprising, considering that the principal function of the sponsoring organizations and their conferences is to promote GRP. Nonetheless, some science did creep in. There were more in-depth technical papers at the Brighton meeting than at the Paris conference.

As a class of materials, the GRP's have a wide range of compositions. In general they are resins containing short glass fiber and a mineral particulate usually calcium carbonate. Pigments and other fillers may also be included but at concentrations that do not significantly affect mechanical properties. The sheet molding compounds (SMC) and bulk molding compounds (BMC) are usually polyester composites that differ in the length of the glass fiber reinforcement. In the BMC the fiber length is about 6 mm or less, while in SMC the fiber lengths are 25-50 mm. The BMC is supplied as rope which can be injection molded into intricate shapes, and because of the short fiber length the reinforcement is more or less evenly distributed throughout the part. The SMCs are supplied as sheet which can be compression molded into wide area parts such as automobile or refrigerator door panels.

The polyester resins are heat cured in the molding process to produce cross-linked, thermosetting plastics. Styrene is the principal monomer and is combined with anhydrides and glycols. When high chemical resistance and high temperature capabilities are required, an epoxy-like polyester is used in which an ethylene oxide adduct of bisphenol-A replaces the glycol.

The formulation of the GRPs vary widely depending on the intended use, and even for a given application different supplier may offer different formulations. Unconcertingly, there can be batch to batch variations of a given formulation from the same supplier. At the Paris meeting Mr. J. Cluet (Silenka-France, Le Chesnay) used the composition diagram shown in Fig. 1 to illustrate current GRP formulations. The dark shaded area on the left of the diagram indicates compositions with too little resin to be moldable. The remaining area represents possible BMC compositions, although the principal BMCs currently available are restricted to the region enclosed by the small open circle. The larger shaded circle denotes typical SMC compositions. The main thrust of Cluet's talk was that the region delineating

the standard SMCs are by no means optimum compositions and that other SMCs are possible with exceptional characteristics with respect to processing, mechanical properties and/or appearance. He has been developing tough, high modulus materials from compositions with essentially equal ratios of glass to resin and very small amounts [illegible] of particulate filler, e.g., close to the [illegible] of the right-hand side of Fig. 1.

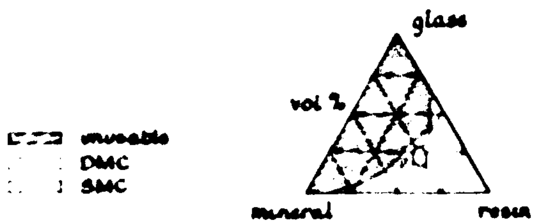


Figure 1

Part of the reason that the standard SMC and DMC have the compositions given in Fig. 1 is that at higher glass concentrations it becomes difficult to get a uniform distribution of the fibers in the molding process. Thus, a high particulate concentration is needed both to maintain viscosity during molding and to provide supplementary reinforcement. Nevertheless, [illegible]'s point is well taken in that higher performance GRP products are attainable with higher glass fiber composites if the fibers are properly distributed in the molding.

Two of the papers at the Brighton conference were on the effect of fiber orientation on the mechanical properties of GRPs. One was by M.W. Darlington (Cranfield Institute of Technology, Cranfield, Bedford, UK) and the other by Dr. M.J. Owen, (Univ. of Nottingham, UK). Darlington has been investigating thermoplastic GRP materials which, unlike the more widely used polyester-matrix GRP, are based on noncrosslinking polymers. The thermoplastic materials can be melt processed but usually do not have the good heat resistance and creep resistance of the polyesters. Darlington and his associates at Cranfield have been working on the effect of fiber orientation on mechanical properties for the past five years. Stressed in the fiber direction, the tensile strength and modulus of GRPs are quite high, but when the stress is transverse to the fibers the strength and stiffness can be as low or even lower than the unfilled polymer itself. Thus, the engineer is faced with having to decide where, between the upper and lower bounds, he should select his design criteria. Darlington has been able to show that the stiffness under a variety of stress distributions can be predicted from the fiber concentration, orientation, and length distribution. Recently, the Cranfield group has found that the creep modulus under uniaxial tension is a surprisingly simple linear function of fiber volume fraction. At Brighton, they reported that the creep rupture strength decreases with increasing fiber concentration, so there is a trade-off between stiffness and creep strength.

It is an unquestioned advantage to be able to predict GRP mechanical properties from fiber distribution, but in a complex molding it is difficult to know this distribution at any given position in the molded part. The question of the effect of molding conditions and mold configuration on fiber distribution has been studied by the Cranfield group and Owen at Nottingham. Owen and his associates have worked on the problem for about ten years, and his presentation was something of a review of their work. In general they find that as the GRP molding compound is injected into the mold cavity, expansion of the flow field causes the glass fibers to be reoriented from their alignment along the flow direction in the injection nozzle. As the compound passes the nozzle gate into the mold, the flow front is curved. Fibers leaving the gate tend to rotate so as to be aligned with the curved front. Shear planes near the mold boundaries and corners can create "welds," i.e., regions devoid of fiber that are thus unreinforced and extremely weak. Flow around

inserts in the mold divide the front and as the divided regions rejoin, shear planes develop and form fiber-free welds.

Clearly, it is important to be able to predict these flow patterns for purposes of mold design or for structural analysis of molded components. However, as Owen pointed out, rigorous prediction requires the development of a rheological equation of state to be used in conjunction with fluid mechanics equations to predict the mold filling sequence and fiber orientation. The difficulties with this approach are formidable, and although efforts along these lines are being made at Nottingham and Cranfield, Owen has been following a simpler track by developing empirical rules for flow prediction. Using simple rectangular laboratory molds and also by examining commercially molded parts, Owen's group have identified certain flow patterns and have developed simple geometric techniques for predicting fiber orientation.

A.A. Taylor (Imperial Chemicals Industries, Ltd, Welwyn Gardens, UK) presented an interesting paper at the Brighton meeting on the rheology of GRP "gel" coatings, which are coatings of pigmented polyester resin that are sprayed or brushed onto GRP surfaces for decoration and weather resistance. Being similar in chemical composition to the polyester matrix of GRP, the gel coat usually adheres well. However, the appearance of the coating will be unsatisfactory if the brush marks do not flow out, the coating sags before drying, or there is pigment segregation. The cause of these problems is the viscosity of the coating which, if too high, does not flow properly or if not viscous enough will sag or allow pigment particles to settle out. These are all very low shear stress flows, and Taylor developed a low shear stress viscometer to relate the rheological response of the gel coatings to their applicability and final appearance. The instrument is a parallel plate viscometer fitted with a friction-free compressed-air bearing for the top plate assembly. To determine low shear stress behavior, the top plate is deflected through a small angle, released and allowed to relax under the action of a light spring. The shear resistance of the coating is measured by the rate of recovery of the initial displacement. The device was also constructed so that the paint could be sheared at a high rate just before measuring the shear resistance, so as to simulate shear thinning of the fluid during spraying or brushing. As might be expected, Taylor found that the best performance coatings were those that shear thinned but then recovered to exhibit high shear resistance within a few seconds; too slow a recovery lead to sag, too fast prevented flow out.

Reports on the mechanical properties of GRP were rather scant at both the Brighton and Paris meetings. Work in this area tends to find its way to meetings on polymer science and usually deals with better defined albeit less realistic filler-polymer composites than the commercial GRPs. There were, however, a few papers on GRP mechanics. In Paris, Dr. M. Marzola [Societa Nazionale Industria Applicazioni (SNIA), Viscosa, Colleferro, Italy] reported on the bending behavior of glass reinforced polyesters and developed general equations for stress and strain distribution based on the theory of mixtures. He has developed general equations that can be applied to differently shaped beams by using various conversion factors. Dr. J.J. Masset (Vetrotex Saint-Gobain, Neuilly-Sur-Seine, France) also at the Paris meeting discussed the inadequacy of the simple falling ball impact test for GRP and showed that the Charpy test gives directly the stored elastic energy and fracture propagation energy. He presented a movie of the effect of specimen size on the fracture mode, i.e., delamination vs. through-fiber fracture.

One of the more technically astute papers of either conference was given at Brighton and was co-authored by G. Caprino and I. Miaolios (both of the Univ. of Naples, Italy) with J.C. Halpin (Air Force Materials Laboratory, Wright-Patterson AFB, Ohio). They made a comparison of two different theoretical approaches for treating composite data: linear elastic fracture mechanics vs. a strength analysis approach which combines classical fracture mechanics with notch theory and which focuses on a notch tip "plastic" damage zone size as a material property. Caprino et al. find that the two approaches give identical results for a variety of fiber-resin combinations and a range of fiber orientations. All testing was done in essentially fiber dominated directions.

The study by Caprino, like those of Mazzola and Massot, was done on continuous filament reinforced materials of both GFRP and CFRP. Caprino et al. comment at the end of their paper that CFRP and GFRP are unique in that toughness increases with stiffness and strength. Isotropic materials, on the other hand, generally exhibit a decrease in toughness with increasing stiffness and yield strength. These authors go on to point out that reinforcement of polymers by particulate fillers increases stiffness but decreases toughness and that the situation in random, short fiber composites is unknown. They suggest that the priority for future study is to determine the transition in properties from particulate reinforcement behavior to the fiber dominated response of CFRP and GFRP.

The buckling behavior of CFRP shells loaded on the convex side was described by I.H. Marshall (Paisley College of Technology, Paisley, UK), who finds that for shells of low aspect ratio, i.e., length to width ratio, the expected behavior of "snap" buckling [illegible] At high aspect ratios, L/D, a [illegible] deflections occur which cause [illegible] snap at loads much less than [illegible] symmetric buckling. He suggests that subcritical buckling could be used for a number of panels and shell (FRP) structures, but it is not tested for nor considered in structural design.

One of the principal themes of the Brighton conference was quality control (QC). A number of papers discussed problems in QC at the materials level in fabrication. In the past, QC has not been a prime consideration for GRP since they were not used in strength-demanding applications. As long as the end item looked pretty, strength and durability were usually of secondary importance. As GRP finds its way into more demanding and costly applications there is a clear need for better reliability and consistency in performance. At this stage the fabricators blame the raw materials suppliers, and the latter blame the fabricators. Both, of course, are equally responsible, and the Brighton papers showed evidence of attempts to develop materials QC controls and the use of on-line inspection schemes during fabrication. G. Ehnert (Owens-Corning Fiberglas Europe SA, Belgium) described the use of x-rays to detect voids, improper fiber distribution, etc., in SMC components during processing.

In order to have good quality control there must, of course, be agreement upon standards. At the Paris meeting, M. Wettly (Assoc. Française de Normalisation, Paris) spoke about standards for reinforced plastics. He restricted his comments to test standards for the raw materials rather than finished products and stressed such points as the need for consistent terminology, international uniformity in standards, and the fact that the development of standards for resins is not as advanced as for glass fibers. He also made the point that existing standards do not relate to performance during fabrication or of the finished product. Present standards are set only to assure material property repeatability.

A topic of great interest in recent years in the reinforced plastics industry is that of pressure gelation (PG) in which the part is cured at abnormally high temperatures and under a continuous pressurized feed of resin. In conventional GRP molding great care is taken to prevent heat buildup from the reaction exotherm. The resin and mold are brought to the cure temperature over a long period of time in order to achieve an even cure with minimum shrinkage and stress. Nonetheless, the resin in the center of the mold tends to cure first, resulting in shrinkage and residual stress. In the PG technique the mold surface is hotter than the cure temperature of the resin, so cure begins from the mold surface and proceeds inward. The pressure of the feed prevents shrinkage. The molding time is short to prevent overcure and scorching. Indeed, fast production is one of the major features in PG. In the two conferences only one paper was given on PG; B.J. Alger (Millitorr Engineering Ltd., Radcliffe, Manchester, UK) described molds specifically designed for PG production of GRP tubing. Most PG work has been done using conventional molding equipment modified for PG, but the results have not been entirely successful. However, the cost of new tooling such as that described by Alger may slow the acceptance of PG by the GRP industry.

As GRP replaces metals, problems can develop because of the poor shielding ability of GRP against electromagnetic interference (EMI). Whether it is a matter of containing radiation from sources such as power tools or

microwave ovens or to protect sensitive microelectronic equipment from EMI, conventional GRP housings are generally inadequate. A related problem is the inability of GRP to dissipate electrostatic charges, and the charge buildup can reach dangerous levels. W.J. Fraser (Premix, Fiber-Glass Div., UK) discussed the problem at the Brighton conference. He noted the impending regulation of EMI pollution by the US and European governments, and without adequate technical guidance these regulations could be overly restrictive. Historically, the solution has been to apply a metal coating by vacuum deposition, electric arc discharge, or painting with conductive paints. Such secondary processing adds significantly to production costs, and the search is on for ways of introducing conductivity into the molding compounds themselves by adding metallic fibers, flakes or powder, conductive carbon fibers or metallized glass fibers. Fraser reviewed the various advantages and disadvantages of each but did not offer any ranking of their effectiveness. In his conclusions he lamented the lack of any understanding of how much EMI shielding is actually needed. The attitude is that since metals provide good shielding, the GRP should be made as conductive as metals. Actually, metal shielding is often an overkill. Clearly, this is an area in need of research.

Many of the papers at Brighton and Paris described the manufacture of specific end items. Some of the more unusual products included a GRP lighthouse and some massive transformer housings. Both of these items were produced by filament winding, which involves the wrapping of roves of glass filaments onto a collapsible mandril. So long as the contour of the item being formed can be generated as a surface of revolution, i.e., cylinder, sphere, ellipsoid, etc., the winding can be done automatically on a lathe-like machine. The roves are wound in a criss-crossing helical pattern so that the mechanical properties in the plane of the wound surface are nearly isotropic. The resin may be applied as the rove is wound (wet winding), or the rove may be supplied preimpregnated with resin. The lighthouse was produced by Chemische Werke Hüls, Marl, Germany and is cylindrical in cross section with a diameter of 3 m and a height of 48 m. A motion picture of the construction and installation of the lighthouse was shown at the Paris meeting.

In Brighton, J. Golding (Ciba-Geigy, Switzerland) described the design and construction of transformer casings 1.7 m high and 2.4 m in diameter. The principal advantages of GFRP in both applications are better weather resistance than conventional construction materials and thus less maintenance. The GFRP transformer casings offer better electrical insulation than metal casing.

Much was said about the use of GRP in housing construction at both meetings. The greatest use is as façade paneling to cover and modernize existing buildings. Similar panels are used as decorative cladding on new buildings. At Paris, T. Greenwood (Amoco Chemicals, Geneva, Switzerland) described the generally wide acceptance of GRP piping and storage tanks by the petroleum industry.

Y. Breval (Société Nationale Industrielle Aérospatiale (SNIAS), l'Estab. d'Aquitaine, St. Médard-en-Jalles, France) described filament-wound GFRP bottles for storing fluids under high pressure. The interior of the bottle is lined with a thin shorting of lightweight aluminum alloy over which glass filaments are wound in a helical pattern. The liner serves to retain the fluid and to distribute the pressure evenly on the GFRP outer shell. The stress in the GFRP is more or less evenly distributed by the helical arrangement of the filaments. The reduction in weight achieved with the GFRP bottles compared to all-metal construction makes them attractive for aerospace uses and scuba diving.

The most "high technology" presentation of either meeting was that given in Paris by J.P. Duphill (SNIAS, les Mureaux, France) on multi-dimensional composites. These so called "3-D" composites have fibers in three orthogonal directions. Special weaving machines knit the 3-D fabric, which is then impregnated with resin and cured. Conventional 2-D laminates are strong in the fiber directions but weak when stressed normal to the fibers. The 3-D materials overcome this problem but at a considerable increase in cost. The fibers need not be the same in all directions so, for example,

stiffness can be made anisotropic by using glass in one direction and carbon fibers in another. Present uses of the 3-D composites are rocket casings and nose cones.

The Brighton and Paris conferences left little doubt that there is considerable activity in the UK and in Western Europe in *verre textile plastiques renforcés*, both technically and commercially, although Europe seems to be a little behind the US and more hesitant to try new GRP applications. At both conferences there were frequent references to US accomplishments that should be emulated. This was especially true in the use of GRP in the automobile industry, where the US has gone ahead somewhat more boldly, with the Europeans waiting for the outcome before plunging ahead. (Willard D. Bascom)

MEDICINE

THE ANNUAL CONGRESS OF THE BRITISH INSTITUTE OF RADIOLOGY - 1979

The Middlesex Hospital Medical School (London) was the site of the 57th Annual Congress of the British Institute of Radiology (*BIR*), held 26 and 27 April 1979. The BIR is a nonprofit organization established by Royal Charter, and it was the world's first national radiological society to be formed after Roentgen's discovery. In contrast to the Royal College of Radiologists, the BIR represents radiology in the broadest sense. It is an organization of physicians, scientists, industrialists, and technicians with equal membership working toward the common goal of improvements in the field of radiology.

After welcoming remarks by the President, Mr. W.M. Ross, the opening address was delivered by Robert Heitzman, MD (Professor of Radiology, Director of the Diagnostic Division, Department of Radiology, State Univ. of New York at Syracuse). He lectured on "Computerized Tomography of the Thorax—Current Perspectives." Although computerized tomography (CT) was invented and developed in the UK, initially only for the head, there are few total body units available in this country. Despite this paucity, Heitzman's lecture was well received and appreciated by his largely British audience.

Heitzman is well known for his many papers and two books that deal largely with radiographic anatomy and radiologic-pathologic correlations of chest diseases. With the advent of CT, he was in a unique position to combine this new modality with his previous experience.

His talk was divided into two sections, CT examination of the mediastinum and of the lung. Although well organized and well presented, it is difficult to reproduce verbally a lecture that was largely dependent upon pictorial representations of the anatomy and pathology. On evaluation of the mediastinum, Heitzman's two major points were: (1) CT examination adds a third dimension to the routine frontal and lateral examinations of the chest. lesions can be seen in profile for better evaluation. In addition, masses may be discovered that otherwise would not be seen; (2) The use of attenuation coefficient numbers (Hounsfield numbers) allows the radiologist to determine the approximate tissue content of any structure in the mediastinum. Heitzman showed various masses containing considerable fat that, because of the low density of fat, are clearly demonstrated and easily diagnosed by CT. He also discussed the differential diagnosis of various masses in the mediastinum from enlargement of the great vessels. In his section on examination of the lung, Heitzman indicated that more pulmonary nodules will be discovered by C.T. than by routine chest tomography, although it is more difficult to tell the nature of any individual nodule by CT. However, he noted that new information from the Johns Hopkins Univ. Medical Center suggests that any pulmonary nodule with a Hounsfield number greater than 175 is almost certainly benign. It is however, quite difficult to obtain an accurate Hounsfield number from a small nodule.

After the opening address, a period of time was devoted to visiting the scientific exhibits that are a traditional component of radiology meetings. One of these was "A survey of mammography in Britain," by M. Fitzgerald and D. White (St. Bartholomew's Hospital, London). This exhibit featured some of the information and results obtained from a survey of eight centers established to obtain dosimetry and image quality measurements at 61 hospitals and clinics in Britain. X-ray tubes

with targets of tungsten or molybdenum were evaluated, using suitable breast phantoms, in combination with 2 kinds of film and Xerox plates. The molybdenum-Xerox group produced the highest mean image score (best image quality) but also the highest mean dose, and the group felt that its use was not justified, particularly for breast screening. Combinations of a molybdenum target and DuPont [illegible] film or Kodak [illegible] film produced satisfactory results and dosage as did the combination of a tungsten target and a Xerox plate.

An exhibit entitled "Low Dose Radiographic Technique For The Detection And Follow-up Of Scoliosis In Children" by D. Ardren, M. Harding, R. Coates, R. Dickens (Univ. of Oxford), demonstrated the technique used at that center to reduce the radiation exposure to children with scoliosis. They recommend a 15-cm air-gap technique with a 365-cm focal spot to film distance. DuPont [illegible] film was used and the radiation exposure reduced by a factor of four.

"Measurement Of Lung Volume From Chest Radiographs," an exhibit by R. Pierce, D. Brown, D. Dennison, and I. Kerr (Brompton Hospital, London), is a computerized technique for obtaining pulmonary volumes from ordinary frontal and lateral chest radiographs. The method requires a spark pen in order to outline the lungs in both projections and subtract the various soft tissue components of the chest. The pulmonary volume is then calculated by the computer. The exhibitors had a 0.96 correlation with helium gas and spirometric determinations of pulmonary volumes. This technique could become quite important as it would allow physicians to follow changes in pulmonary volumes directly from routine radiographs without the patients having to undergo pulmonary function examinations.

J. Husband, D. Mears, and P. Trott (Royal Marsden Hospital, London) exhibited their technique for "CT Guided Aspiration Biopsy Of Pancreatic Masses." Pre-operative diagnosis of carcinoma of the pancreas could eliminate diagnostic surgical exploration. The authors of this exhibit demonstrated how a thin needle can be placed into the pancreatic mass under CT guidance and an aspiration biopsy obtained with no significant patient morbidity.

"Reduction Of Patient Dose In Xeromammography By Added Filtration" by M. Baker, R. Davies, D. Dance, C. Parson, (Royal Marsden Hospital, London) was a useful demonstration of how added filtration will reduce the radiation dosage significantly while scarcely affecting image quality. Up to 2 mm of aluminum filtration can be added without significant loss in detail. (Al filtration of 1 1/2 mm was instituted throughout The National Cancer Institute/American Cancer Society breast cancer detection centers in the US approximately 3 years ago.)

"Ultrasound Angiography" was an interesting exhibit by C. Wood and H. Meire (Clinical Research Center, Harrow). The scientists in this case use a Doppler technique for ultrasound demonstration of normal and abnormal blood vessels. It is not likely that ultrasonography will replace contrast angiography, but an ultrasound technique could be considerably useful as a screening examination for significant arterial disease.

"A Detachable Balloon Technique For The Treatment Of Lesions Of The Internal Carotid Artery," by C. Hawkins and S. Crimson (Addenbrook's Hospital, Cambridge), is a remarkable treatment for aneurysms of the large vessels within the brain. These vessels are notoriously difficult to reach surgically and aneurysms are difficult to resect, even if they can be properly exposed in the operating room. The balloon technique is done without surgery and consists of fluoroscopic guidance of a balloon through the artery into the aneurysm. The balloon is then filled with a suitable material that fixes it permanently within the aneurysm. Preliminary results have been good, but insufficient time has passed for long term follow-up.

Two complementary papers, one by R. Heitzman and the other by J. Husband and I.K. Fry (Royal Marsden Hospital and St. Bartholomew's Hospital, London) were devoted to computerized tomography. Heitzman discussed connective tissue planes of the mediastinum. He demonstrated to good advantage the position of posterior and anterior thyroid masses in the mediastinum and how these masses are deflected by mediastinal fascial planes and vascular structures. The same would be true for abscess masses. He also demonstrated that the perivisceral space

surrounding the esophagus and trachea is continuous with a peribronchial space leading into the lung. This space is undoutedly the route taken by infection or lymphoma when it spreads from the mediastinum into the lung. Husband and Fry's paper outlined their major uses for CT of the chest: (1) Evaluation of abnormal chest radiographs, (2) Detection of occult primary tumors, (3) Staging of neoplasm. These authors nicely demonstrated how CT evaluates the abnormal mediastinum, and their observations were similar to those made by Heitzman. They also demonstrated in a group of normal patients a large variation in the amount of remaining thymic tissue that accounts for some of the differences in the radiographic appearance of the normal mediastinum. In the last part of their paper they evaluated CT in the TNM staging of testicular neoplasm.

A paper by R. Grainger (Hallamshire Hospital, Sheffield) demonstrated the continued necessity for angiographic evaluation of mediastinal masses despite CT. Grainger demonstrated various vascular anomalies and vascular masses of the mediastinum. The three papers covering the mediastinum were juxtaposed to good advantage.

Several papers were presented from The Hospital for Sick Children (London), of which two dealt with various aspects of pediatric neuroradiology. The first of these, by R. Hoare, dealt with various lesions of the pineal region as evaluated by CT, and the second was a very interesting paper by B. Kendall, demonstrating that leukodystrophy can be evaluated particularly well by CT. Many examples of the differential diagnosis of leukodystrophy from multiple other lesions that affect the white matter of the brain were displayed. Leukodystrophy is an abnormality of the myelin sheath of the white matter of the brain. In this illness the myelin is replaced in a bilateral and symmetrical fashion by glial cells. There is progressive atrophy and a poor prognosis, which makes a differential diagnosis from other lesions of some importance.

Another pediatric paper by I. Gordon on the value of krypton ventilation studies in children was carried out using ^{81}Kr. This isotope has a very short half life of 13 sec and is generated from ^{81}Rb. The author demonstrated how both medical and surgical therapy for various pediatric diseases, particularly cystic fibrosis, can be evaluated particularly well by this technique in combination with the ^{99}Tc perfusion scan.

The highlight of the meeting was the Silvanus Thompson memorial lecture delivered by Prof. G.E. Adams (Royal Marsden Hospital, London). His subject was "The Past, Present and Future of Hypoxic Cell Sensitizers." The speaker was clearly not only a master of his field but had complete command of his material and his delivery was exceptionally good. He outlined the history of his subject and led the audience up to the present and into the future. The essence of the problem he discussed is that tumor cells are hypoxic, but radiation has a much greater effect on well-oxygenated cells. The problem, therefore, is to find a way of delivering oxygen to the hypoxic tumor cells or of finding a chemical mediator that will act like O_2, and sensitize hypoxic cells to radiation or drugs. The author stated that oxygen is not unique in this regard but is one of a large class of radiation sensitizers. He also indicated that hyperbaric oxygen therapy is probably not the most efficient method of sensitizing hypoxic cells. Adams discussed a series of sensitizing compounds tried over the years, the most hopeful of which is misonidrazole. This compound is an excellent sensitizer of hypoxic tumor cells, markedly increasing their sensitivity to radiation. However, misonidrazole is toxic and produces a peripheral neuropathy. The radiation therapist Dr. S. Fische, (London) has determined that the maximum permissible dose of misonidrazole is 12 gms/m^2, which is less than the most effective amount for sensitizing hypoxic tumor cells. At the present time compounds closely related to misonidrazole are also being evaluated and therapeutic trials are under way in order to determine a therapeutic ratio for misonidrazole and similar compounds. (A therapeutic ratio is the toxicity of a compound in relation to its effectiveness—a true test of its usefulness.) The outlook for misonidrazole itself, because of its toxicity, is not as hopeful as it was a short time ago, but the therapeutic trials currently underway must be completed before conclusions can be drawn. These trials may demonstrate that one of this group of compounds will lead

to a much improved sensitization of hypoxic tumor cells within the limits of toxicity and brighten the future for cancer therapy. (Irwin M. Freundlich)

METROLOGY

PRIMARY LABORATORY FOR TIME AND FREQUENCY, PARIS

Until 1956 time was defined in terms of the earth's rotation, and so astronomical observatories provided the time standard. Since 1960 the second has officially been the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

Although time is thus no longer the responsibility of astronomers, the Paris Observatory at the southern end of the Avenue de l'Observatoire, Paris XIV (just south of the Jardins de Luxembourg), now houses a number of organizations that have taken over the services it had provided in this field since its founding in the seventeenth century. One of these is the Laboratoire Primaire du Temps et des Fréquences (LPTF), established in 1976 as one of the four primary laboratories of the Bureau National de Métrologie. Another tenant of the Observatory is the Commission Nationale de l'Heure (CNH), set up in 1967 to distribute time standards throughout France, and a third is the Bureau International de l'Heure, which coordinates time standards on a worldwide basis. The CNH takes as its standard the average of a dozen cesium-beam clocks in various parts of France, including five at the LPTF, and it transmits time signals from its radio station at Allouis in the geographical center of France on 163.84 MHz with precisely controlled carrier phase.

In keeping with its name, the LPTF is divided into two parts: the Service National de l'Heure (SNH) and the Laboratoire de Métrologie des Fréquences (LMF). The SNH, with six or eight people, maintains the French time standard in collaboration with other organizations and further assists the CNH by providing information on the time via radio, TV, and telephone (hourly signals, time-code pulses, and the speaking clock).

The SNH also investigates and applies methods for time comparison, including the use of LORAN C signals, transportation of clocks, and transmission via TV, satellite, and very low frequencies. Since 1968, special timing pulses have been transmitted in France on both 819-line and 625-line television during the vertical-retrace interval. These have served to compare Cs clocks in different parts of the country after taking account of the propagation delays in the TV network and in electromagnetic propagation, permitting comparisons at present to within a few nanoseconds (1 nsec = 10^{-9} sec). [See P. Parcelier (LPTF), "Time Synchronization by Television," *[illegible]*, IM-19, pp. 233-238 (Nov. 1970).] The coordination of clock comparisons by TV is handled by the SNH, which has on occasion used this method internationally. In the latter case, however, the variations in TV network delays with changes in routing considerably reduced the achievable precision. The LPTF's monthly bulletin carries information on the discrepancies between sources of timing information as determined by the SNH.

In collaboration with the LMF, the SNH studies the fluctuations of atomic clocks, which are a particular interest of Dr. Jacques Rutman, Deputy Director of the LPTF and author of "Characterization of Phase and Frequency Instabilities in Precision Frequency Sources," *[illegible]* 68, pp. 1048-1075 (Sept. 1978). Most ^{133}Cs clocks are stable in frequency to within 1 part in 10^{11} (0.1 Hz), while the best are a couple of hundred times as good, but over long periods their time readings inevitably develop increasing random errors. On account of the "flicker phenomenon," the spectral density of the variations in frequency f behaves as $1/f$ at the lowest frequencies, creating difficulties in characterizing the FM because the integral of $1/f$ is infinite. Rutman has studied a variety of measures of frequency variation, including several whose responses to the low-frequency components fall to zero fast enough to circumvent this problem.

Rutman received his doctorate in 1972 from the Univ. of Paris VI (Université Pierre et Marie Curie, two kilo-

meters northeast of LPTF) under Prof. Jean Uebersfeld, who is now vice president of that campus. A close collaboration continues between LPTF and UPMC, where Rutman gives courses and from which a number of other LPTF staff members also have come, e.g., P. Plainchamp, who recently completed his doctoral research there on the stability of the 4.25-THz CH_3OH laser pumped by a CO_2 laser (1 terahertz = 10^{12} Hz).

Uebersfeld is quite interested in the flicker phenomenon, which has been observed to persist down to 10^{-7} Hz with a level independent of temperature. Improvements in quartz resonators have recently reduced the flicker noise by 10 to 20 dB; this noise falls as $1/\Omega^2$ when their when their Q is large. Uebersfeld conjectures that the flicker phenomenon arises from macroscopic defects in the oscillator. For a thorough presentation of the state of knowledge concerning this effect, he recommended the *Proceedings* of the Symposium on $1/f^n$ Fluctuations held in July 1977 under the leadership of Prof. T. Musha, Dept. of Applied Physics, Tokyo Institute of Technology, Nagatsuta, Midoriku, Yokohama, Japan.

Other LPTF personnel, such as Dr. Juan J. Jiménez, were drawn from the Institut d'Electronique Fondamentale of the Univ. of Paris XI in Orsay, where Jiménez received his doctorate in 1974. There has also been close cooperation between the LPTF and the National Bureau of Standards in Boulder, CO, where Jiménez spent a year. F. Russell Petersen of NBS, in turn, spent a leave of absence at LPTF.

The LPTF's Laboratoire de Métrologie des Fréquences (LMF) has a staff of five people concerned with the development of frequency standards and with the measurement of optical frequencies as well as with the previously mentioned work carried out jointly by the LMF and the SNH. In the cellars of the Observatory, well isolated from vibration and temperature fluctuation, this group has, with the assistance of NBS and groups at UPVI and UPXI, constructed copies of two NBS laser-frequency-synthesis chains linking a helium-neon laser at 88.3 THz (3.39 μm) to a Cs-beam clock via a series of microwave oscillators and lasers at intermediate frequencies. Successive links are joined by means of nonlinear devices that beat one input with a harmonic of the other and, in some cases, with an additional klystron's output to bridge the remaining frequency difference.

The earlier design was executed in 1977 at LPTF and has also been implemented at the National Physical Laboratory in Teddington, Middlesex, UK, which is responsible for British standards. The improved chain, completed this year at LPTF, employs a superconducting cavity for stabilizing the lowest-frequency (Gunn-effect) oscillator, as a loaded Q of about 10^{11} can be achieved in this way, yielding a short-term frequency stability better than 10^{-13} and a long-term drift of $\pm 2 \times 10^{-13}$ per day [S.R. Stein and J.P. Turneaure (NBS and Stanford Univ.), *Proc. IEEE*, 63, pp. 1249-1250 (Aug. 1975)]. A Josephson junction is used to multiply this oscillator's 10-GHz output frequency by 425 to reach the CH_3OH laser frequency, thus reducing the number of links needed in the chain. Improvements in the lasers allow this one, along with two CO_2 lasers, to suffice in reaching the He-Ne frequency. By using the Cs clock to count the frequency of the microwave oscillator, the LMF expects to be able to measure any frequency between 25 GHz and 5.8 THz with an accuracy better than 10^{-12} for both spectroscopic and industrial-laser applications.

With further improvements in nonlinear devices it is hoped that frequency measurements can be extended to the visible range. The highest operating frequency so far realized has been obtained with a metal-insulator-metal (MIM) point-contact diode at NBS, and LPTF is fabricating MIM diodes in an effort to push them beyond 200 THz. The Laboratory has succeeded in producing a contact point with radius less than 50 nm (0.05 μm) by electrolysis of a 1-mil tungsten wire. The other metal is nickel; the oxide insulating layer between the W and Ni is 2 nm thick.

Since 1966 the international standard of length has been the radiation corresponding to the transition between the $2p_{10}$ and $5d_5$ levels of the krypton-86 atom; the meter is defined as 1,650,763.73 times its wavelength (605.78 nm). With the extension of the frequency-measurement chain to such visible frequencies as the 495 THz of ^{86}Kr, the standards of time and length can be unified, and it will be possible

to replace the Kr lamp with a stabilized laser to provide a better definition of the meter. Alternatively, a single standard could serve to define the units of both time and length if a conventional value should be adopted for the speed of light.

Just as radio waves, formerly denominated in terms of wavelength, are now generally described in terms of frequency, it appears that infrared and even light waves are undergoing a transition from Ångströms or nanometers (1 nm = 10 Å) to terahertz, as chains of oscillators are gradually making it possible to count their oscillations. Progress in the accurate measurement of time and frequency involves painstaking efforts toward equally precise standards in many countries, and France is endeavoring to catch up with the US and, if possible, to surpass it in particular types of stabilized lasers or nonlinear devices. Among the beneficiaries of better time and frequency standards will be navigation systems, geodesy, long-baseline interferometry, communication systems, and relativistic research, some of which already require time information accurate to a very small fraction of a microsecond. As such precision becomes more widely available, it will permit a wider scope for both research and technology. (Nelson M. Blachman, GTE Sylvania Systems Group, Mountain View, CA)

OPERATIONS RESEARCH

OPERATIONS RESEARCH IN GREECE

While Greece is less developed than the industrial countries of western Europe, it is much more developed than the evolving countries of Africa and the Middle East. This is especially true of its infrastructure, and operations research and the systems viewpoint seem to come rather naturally in Greece. There is a large and active OR Society, many members of which seem to be doing very good operations research, in spite of the fact that there is very little operations research education in Greece. Some have taken graduate instruction in operations research in the US or the UK; others seem to have picked it up in an OR course somewhere, or else by osmosis.

For example, the public Power Corporation (*ESN* 33-7:275) has an Operations Research Section, with five professionals and two aids. The two professionals with whom I talked were Dr. Polyzos, who took his doctorate in OR at Johns Hopkins, and Mr. Anastios Vilaetis, who took a Master's degree in OR at the Univ. of Detroit. The other three were either trained in Greece, or not trained at all in OR. They work with the consultancy of Prof. D.A. Xirokostas (see below) and seem to have done a lot of useful, hardheaded work. Examples listed by subject are:

Power Dispatch—The section has implemented a quadratic programming optimization of economic power dispatch. (The quadratic cost function comes from the I^2R loss in the lines.)

Manning Levels—The section set up a model to determine whether the various distribution areas are overmanned or undermanned, by predicting a standard manning level based on such variables as the load in the area, the number of customers, climatic and terrain factors, and the like. There was no specific implementation of the model, the results were discussed with appropriate managers, but in general the principal value of the study was negative; that is, the investigators were able to demonstrate quantitatively that there were, in fact, no significant unexplained deviations from one area to another. (This is one of two of such studies published in refereed British journals).

Manpower Forecasting—This relates to and follows the manning studies discussed above and is the first step in manpower planning. A factor analysis showed that manpower requirements depend primarily on three variables: 1) the number of customers; 2) the amount of high-voltage energy; and 3) the length of the network, as measured by the number of transformers. A regression analysis on these variables was carried out to formulate appropriate predictions.

Materiel Inventory Control—This is classic inventory theory applied in some imaginative ways. It has been partially implemented and has been published in a refereed British journal.

Pole Maintenance—The decision problem is how often to inspect the low-voltage poles. If on inspection a pole proves to be defective, it can be replaced. Failure to do so may lead to

a rather expensive outage. On the other hand, the inspection procedure itself is expensive, and so clearly there is an optimal time for inspection. The conclusion of the study was that the inspection period should be lowered from 15 years to about 10 or 12. Again this is classic maintenance theory applied in novel ways.

These few examples are cited out of dozens available to indicate that operations research in Greece, or at least in this corporation, is relatively mature. These professionals are able to use sophisticated techniques when appropriate and have a keen eye for applications and for the nature of the real world.

The Operations Research Society of Greece (HELORS) has over 500 members and in Athens they were able to turn out an audience of well over 50 dues-paying members to attend a lecture that I gave in English. English is, of course, the most common foreign language in Greece. The first president of the Greek Operations Research Society was a General, and there is still strong operational research study in the military. The Navy, for example, has about 45 people in OR, headed by a Captain Rallis, who took his MSc in OR at Cranfield Institute of Technology (Bedford, UK). His opposite number in the AF, Colonel Papoutkis, has an MSc in Aerospace Engineering from Columbia Univ., and he also studied operational research there.

The level of sophistication in operations research is all the more surprising in view of the comparatively small amount of education in this field given in Greece. Most of the OR practitioners appear to have been trained in engineering, economics, and other related fields and to have picked up operations research somewhat incidentally. There are only two chairs in operations research and related fields at the National Technical University (Polytechnion) in Athens; one chair at Thessaloniki, which is the second largest city in Greece; one chair at Patras, which is the fourth largest city in Greece (the third largest, if Athens and its suburb Piraeus are considered to be a single city); and a chair at the University of Athens, which is currently vacant. A new university is being built in Crete where an operations research chair may be created.

In Greece education is free. This is not merely a custom or regulation, it is actually written into the constitution. It is somewhat difficult for students to be accepted by a university, most hire tutors to prepare for the entrance examinations if they are to be successful applicants. But once they are in, there is no tuition, all books and dormitories are free, and the food is highly subsidized. More than 90% of the entrants graduate. Of course, the ranks in the more difficult courses, such as engineering and mathematics, are depleted, many students finding these more difficult than they anticipated.

There has been a good deal of activism among the students at the universities in Greece. The walls of the National Technical University are covered with graffiti and the students frequently strike. Last year they had a very serious strike that resulted in losing half a semester. One professor said to me "this was the first time a strike had cost the students anything." In the past the administration had always given in to all student demands. This year so far there has been no trouble, but everyone is holding his breath. It is also true that students tend to stay away from lectures in large numbers. This may be caused in part by the very crowded lecture halls. Typically, of the 250 students in the first OR course (7th semester) at an average lecture only about 125 students are in attendance.

At Patras the chair is held by Professor Sissouras, a friendly, enthusiastic Zorba-the-Greek type of man. He took his doctorate at the Univ. of Manchester in OR in health systems and is now working on optimization of ambulance and emergency health services in Athens. He teaches the only course in OR, a two-semester course, optional for all engineers in the fourth or fifth year. There is no degree in OR. There are no Master's students (MSc degrees are not given in Greece) but there are three PhD students. I talked with one of these, George Megalokonomos, whose bachelor's degree was in electrical engineering at Patras. His thesis topic is a production case study in the local textile industry.

The Univ. of Patras is on one of the loveliest campuses I have seen.

It is on the Peloponnesus and fronts on the gulf looking northward across to the mainland of Greece. Behind it are snow-capped mountains. The campus is 10 years old and now has 7000 students; it will be expanded shortly to 20,000 students.

We stated above that there are two chairs related to operations research at the National Technical University. Nominally, there is only one chair, held by Prof. D.A. Xirokostas, who took his doctorate in electrical engineering in Birmingham (UK) in stochastic optimal control. The other chair, held by Prof. Ioannas Pappas, is called Industrial Management. Both chairs are in the faculty of Mechanical Engineering. Both give primarily undergraduate instruction, namely a five-year bachelor's degree, with a small number of doctoral students. In the third year Pappas gives a two-semester course in production management and business administration to students majoring in industrial engineering, production engineering, and mechanical engineering. Some of these students also take a course from Pappas in the sixth semester on business games and statistics and in the eighth semester on work study, economics, and production planning and control. In the ninth semester there is more economics and more production planning and control. Students also take some courses in the seventh semester in engineering economics from the economics chair, and OR courses given by Xirokostas in the seventh, eighth, and ninth semesters.

Actually, Xirokostas and Pappas are not as busy as this makes them sound. These courses are given by their respective chairs, but that may mean that they are given by assistants to the professor in that chair. Associated with Pappas' chair, for example, there are a Dr. Iordanides, who holds a rank which might be translated into something like associate professor, and Drs. Theoglon and Samouilidis, two senior assistants, all of whom share in the teaching load.

The University does not use the concept of contact hours, but when I asked Pappas about this, he said he averaged about five, plus two in the Operations Research Center of the National Technical University. Pappas is the Director of this Center, whose primary function is to give post-university training to appropriately technically trained people with a bachelor's degree as a minimum in a technical area (engineering, economics, science, math). It is a full-time course, with a certificate given upon satisfactory completion. Because of the constitutional provision for free education, the Center is not allowed to charge a fee for this course. Partly as a result of this, some students don't take the course very seriously, and there are many dropouts in the first term. While Pappas and Xirokostas are given additional pay for teaching in the OR Center, it is only 500 drachmas (about $15) per teaching hour, which is essentially nothing.

As stated above, there is no MS or MSc instruction, and there are no classroom-type doctoral courses in Greece. The few students who do get doctorates do it purely on the basis of research. Xirokostas and Pappas each have two or three students. On average there is much less research done and published by the staff than in a corresponding American or British university. However, all the OR people have consulting contacts that allow them to do a lot of interesting research, which occasionally leads to publication. (Robert I. Machol)

THIRD INTERNATIONAL CONFERENCE ON OPERATIONAL RESEARCH AND MANAGEMENT SCIENCE

The Conference bearing the above impressive name convened in the Belsfield Hotel in Bowness-on-Windermere in the English Lake District at 1430 on Tuesday, 3 April 1979 and concluded at 1130 on Friday, 6 April. Wednesday afternoon was free for sightseeing, but the rest of the time, from 0900 to 1800, was well filled with technical sessions. The idea of starting and ending at midday, so that people can travel in the remaining half day, is one of several ways in which this meeting was different from the run-of-the-mill technical conferences on OR/MS. Another difference was that it took a middle course between the elite by-invitation-only, and the usual open-to-all conference, by having speakers by-invitation-only but attendance open to whomever wanted and could afford to come. The latter was nontrivial, since the

tee of £120 covered only registration, a couple of cups of tea, and some sherry at the reception on the first evening. Furthermore, the discussion of papers was differently organized than usual: one hour was scheduled for the delivery of each paper, and another hour on the following day was scheduled for its discussion.

Each of these differences has its advantages and disadvantages. The travel-time arrangement was particularly convenient because a majority of the attendees came from, or through, London, and if one lived in London, the scheduling was just right to have a comfortable breakfast and then take a train to the conference. After it was over, one could also leave in plenty of time to get home for dinner.

The Lake District (technically, the county of Cumbria, formerly Westmoreland) is in the northwest corner of England, and can only be reached from most of England after a fairly lengthy car or train trip. However, it is one of the most attractive parts of a generally attractive country and a charming location for a conference. While it was still pretty cold at that time of year, and there was snow on the surrounding hilltops, the countryside was magnificent. In addition, there is a great deal of history, including Wordsworth's cottage and, in Bowness, an ancient church that may be the origin of the American flag. The church of St. Martin dates substantially from 1483, although an earlier church existed on the same site as long ago as 1203. The east window is made of ancient stained glass, most of it dating from the 15th century, but some being earlier, and some of it damaged in Cromwell's day, and repaired as recently as the 19th century. On the ancient glass at the top of this east window are the coats of arms of several local families, including the Washington's. This coat of arms, "Argent, two bars and in chief three mullets gules" on a silver background two red bars and three stars is supposed to be the origin of our stars and stripes. Certain it is that Westmoreland county in Virginia, site of Mt. Vernon, is taken from the old name of this district, brought over by early settlers including the Washington family.

A conference in which all of the papers are first-rate is, of course, everybody's dream. I doubt that this was (or could be) achieved, but surely there were fewer second-rate papers here than in most conferences. There were three plenary sessions, and during the five time periods set aside for technical presentations (complemented by five additional time periods for discussion), there were three papers in simultaneous sessions, so there was usually little difficulty in finding at least one that one wished to hear. However, this very eliteness contributed to the high cost of the conference. There were only about 80 attendees in all, and more than half of them received some sort of subsidy: partial remission of fees for session chairmen, full remission of fees for speakers, and complete subsidy (including travel) for the Sussex staff and for two distinguished speakers, one from the US. This, while there was a small profit, it could have been turned into a loss by a slightly smaller attendance. Such profit as there was "will be wholly devoted to supporting Operational Research in the University of Sussex." It was Prof. B.H.P. Rivett of the OR Department at Sussex who organized and ran the conference and its two predecessors, one at Oxford in 1973 and the other at Stratford-upon-Avon in 1974. In fact, it was very much of a one-man show, with Rivett choosing the speakers and generally determining the form of the conference.

The method of discussion did not work as well as one might have thought, but other methods don't work very well either. In many conferences there is token discussion, which is not very satisfactory, and frequently discussants who have not had time to organize their thoughts give disjointed presentations. Here the discussion was opened a day after the original paper, presumably with the same audience present, by a designated discussant who was allotted ten minutes. Occasionally he used his ten minutes to ignore the original speaker and give a speech of his own on the same topic, but mostly these discussions were very analytical and very thorough. They tended to be followed by one or two well-thought-out presentations that had nothing to do with the beautiful outline laid out by the discussion leader (because they had been written before his presentation), and then followed by a discussion that was not very different from what it would have been had the discussion

[Imm]ediately followed the original paper. [Ho]wever, I never saw the discussion [f]lag; that is, an hour never seemed [t]o be too long, and it was good to have [th]is opportunity to really to chew over [...] presentations.

The stated [obj]ective of the con[fe]rence was to expose a range of cur[rent] activities in Operational Research [an]d Management Science [...] constructive [cri]ticism," and this was to be done [...] into the [fo]llowing pattern [...] a description [...] [illegible]

[illegible]

[illegible] Kendall [...] distinguished [...] brilliant speaker, [...] talk entitled "The [...] fragmentary [...]." [...] particular talk, which [...] was essentially identical to one he had given four years earlier. It turns out that Rivett had heard that presentation, been fascinated by it, and asked Kendall to repeat it for us.

Kendall started by pointing out that quite complex maps can be accurately reconstructed, given no information except which regions abut which other regions. He showed, for example, the map of the 88 mainland departments of France and then a new map that was remarkably similar to the original, yet it was constructed by a computer which had as inputs only the incidence matrix of such abuttal information. He then went to a problem which was similar except that some of the abuttal information was missing; namely, reconstitution of the Manor of Whixley, whence his ancestors had come. In the written surveys of such a manor, one finds that individual parcels are [illegible], each is divided into parallel strips, and in describing it, the surveyor will say that its strips "run from A to B" where A and B are the names of other parcels, which we now know abut the one in question. Clearly, a complete set of such information would be sufficient, but it does not exist. Since the parcels are rectangular, each has in general four neighbors, and it turns out that on the average we have information on about three; it also turns out that theoretically the problem is soluble if and only if there exists information on an average of at least three neighbors. Thus, the data are on the borderline of what is necessary, and a computer program has been worked out which has "the advantage (over earlier 'hand' methods) that the degree to which subjective judgments are employed can be carefully controlled."

Rivett then described a problem on which he was working that adapted the same tool, namely, "The Use of [Loc]al-Global Mapping Techniques in Analysing Multicriteria Decision Making." The idea is to construct a "map" of utilities or preferences, based on an incidence matrix similar to Kendall's, that itself is based on indifferences. That is, if one knows that the decision maker is indifferent between A and B, he can make them adjacent on a map, and if all goes well, at the end of the map construction the most preferred alternative will be at the top and the least preferred at the bottom. One

trouble is that it is as likely to be the other way round—that is, this technique uses only the indifferences and not the preferences. If there is indeed a considerable amount of preference data available, then this technique, which requires discarding such data, may not be very rewarding in the multicriteria decision problem. This provocative research is still underway, and we heard only a progress report.

The final plenary session, at the end of the conference, consisted of a paper by Russell Ackoff (Univ. of Penn.). He entitled it "Ten Principles of Practice, or How to Stand Pat," and since everyone knew that the organizer of the conference is Ackoff's good friend, known universally as "Pat" Rivett, the double entendre was lost on none. Ackoff is known to be provocative. Among his ten principles: Since Humpty Dumpty can't be put together, don't let him fall; do not seek complex solutions to simple problems; don't try to cure a headache by brain surgery. As an example of the last, he told of a production scheduling problem that could not be solved by working on the production system, but that could be solved by working on the marketing system. Specifically, the production difficulties were due to a number of products of which each sold only in very tiny quantities, but which the salesmen insisted the company had to supply if they were to retain their customers for the profitable products. It turned out that when the salesmen's commission scheme was altered so that they earned more on the other products and nothing for selling these undesirable ones, the customers stopped demanding them, and the production scheduling problem disappeared. Thus each of the principles was exemplified by some startling success from Ackoff's consulting practice. His tenth principle was "Never agree to summarize a conference.". This, of course, he had not done. He had merely told some marvelous anecdotes, some old, some new, about operations research.

Of the technical papers in the simultaneous sessions, I enjoyed one by R.M. Stark (Univ. of Delaware) on competitive Bidding. The amount of money involved in contracts let after competitive bidding is staggering, and there is much OR/MS literature on this subject, but it appears not to have affected bidding practice noticeably. Stark feels that this is largely because such papers are not sufficiently realistic. For example, they often assume that the bidder has a perfect estimate of the cost of the project and is in a game-theoretic situation vis à vis other bidders. Stark feels that estimating is at the heart of the problem and spent most of his talk on "a new science of estimation." He mentioned in passing an interesting mathematical insight on the estimation problem on which he elaborated during the (fortunately) lengthy discussion period. He defines a pair of dual problems in geometric programming, one of which is related to the estimates and the other to the costs. In the stochastic case, a linear combination (sum) of the stochastic cost coefficients in the primal yields a geometric form (product) of exponential functions of the cost and constraint coefficients in the dual. Hence the former tends to a normal distribution in the limit and the latter to a lognormal distribution. The theory of duality says that the optimal solutions to the dual problems must have the same value. Hence we have an indication here that the predesign cost estimates and the post-construction costs, both of which are random variables, should not only be unequal in general, but do not even come from the same distribution—and we have some feeling for the skewness of distribution of costs.

Prof. Samuel Eilon (Imperial College of Science and Technology, London) gave a paper on production scheduling which also was not a new paper. Rivett had asked him to repeat the paper he had given at the IIOKS Conference in June 1978. (These were exceptions—most of the papers at this Conference were new.) This more nearly followed the paradigm (page 382) for papers in this conference, at least as far as parts (ii) and (iii) were concerned. His examination of the methodology was in terms of taxonomies: static vs dynamic, deterministic vs stochastic, single product vs multi-product, single period vs multiple period, single machine vs multi-processing facilities. His suggestions for improvement were generally related to an additional dichotomy: theory vs practice. "We have to ask ourselves some searching questions about the applicability and scope of mathematical modelling, and about its shortcomings, particularly with regard to its complexity, validity, accuracy, and flexibility."

The discussion leader the next day was A.D. Jacher, who asserted that while the bulk of Filon's paper was nominally on taxonomy, it actually tells us those things not worth doing any more (that is, models already developed to a high degree of sophistication, for which additional sophistication is hardly worthwhile because they aren't really applicable—and since Jacher is a well-known first-rate mathematician, he can say these things). Most of Filon's report, Jacher said, involves cutting down the combinational complexities of scheduling problems; he also pointed out how the improvements in digital computers had changed things in scheduling. Finally, he felt that the future successes would lie in on-line activities, as in job shops. Filon responded that he did not disagree with this, but that he had reviewed research on production scheduling, not the problem itself, and he had specifically stated that in spite of the great achievements in research, there remained much inefficiency in production practice. His purpose had been to castigate research workers, not to be pessimistic, and he hoped that research workers would work on the on-line problems as Jacher had suggested.

A final comment from the floor came from Keith Chesterton, a production controller for Lever Bros. in the manufacture of soaps and detergents. He said that most of his time was spent responding to interruptions in supply and to changes in production scheduling which were caused by marketing. Under the circumstances he wanted more in the way of heuristics applicable on short notice to suddenly changed problems. The academics agreed that the researchers had not supplied as much of this as they might.

While these papers were not necessarily "typical," the above description should at least give the flavor of the kinds of papers and discussions at this thoroughly enjoyable conference.

Robert E. Machol

ONRL REPORTS

See the back of this issue for abstracts of current reports.

OPTICAL PHYSICS

RECENT DEVELOPMENTS IN GAS LASERS

Oxford University hosted 99 attendees from 10 countries (including the USA) who participated in a conference on "Recent Developments in Gas Lasers," on March 21 and 22, 1979. Shortly before, Dr. A.N. Smiley (formerly ONRL Liaison Scientist for Optical Physics) and the author visited Prof. Colin E. Webb (Clarendon Laboratory, Oxford Univ.) and discussed with him some of his group's research efforts in the field of gas lasers. The following paragraphs report on observations by Smiley and the author of research by Webb and his group and on some of the recent advances in gas lasers at Oxford and elsewhere as presented at the conference.

The laser group at Clarendon Laboratory was founded by Dr. John Saunders, who as long ago as the late 1960's proposed possible mechanisms for producing laser action in gasses. Colin Webb was Saunders' first graduate student in laser physics and upon completing his studies at Oxford, Webb spent four years studying charge transfer reactions at Bell Laboratories. Since his return to Clarendon in 1968, he has been the leader of a group that has a very productive history in the field of gas lasers.

Among the important contributions made by Webb's group are: Investigations of charge transfer excitation processes in gas discharge lasers. [T.A. Piper et al., "Excitation Mechanisms of the cw He-As Laser," *J. Phys. B: Atom. Molec. Phys.* 11, 3731 (1978).] According to Webb, they have developed the first "good" hollow-cathode metal-vapor laser, and in this laser observed arsenic ions. These lasers are based upon charge transfer reactions between ground-state helium ions and neutral metal atoms, as in

$$He^{+}(^{2}S_{1/2}) + As \rightarrow He + (As)^{+} + \Delta E.$$

Powers as high as 1/4 W have been obtained from a zinc laser of this type. They have also developed the first

copper vapor laser which is operable at room temperature. Elemental-copper vapor lasers operate at about 1500°C, and copper-halide vapor lasers from 300° to 600°C, leading to problems typical of high-temperature devices: materials which have widely different thermal expansivities, and difficulties in providing vacuum joints and electrical feedthroughs. Laser action in their new copper acetylacetonate ($Cu(C_5H_7O_2)_2$) device was observed with wall temperatures varying from 20° to 140°C. It was found that laser power increased with temperature to a saturated value at 40°C. Finally, they have improved discharge-pumped excimer lasers by moving the capacitors inside the gas mixture, immediately adjacent to the discharge electrodes. This design minimizes the inductance of the leads and hence optimizes the pumping pulse shape.

In addition to his research and teaching duties in the Physics Department at Oxford, Webb finds time to work with a new company, "Oxford Lasers," which he and his colleagues founded. They are producing discharge-pumped excimer lasers, and their Model 8X2 can operate with the rare gas halides ArF*, KrCl*, KrF*, XeCl*, and XeF*. Specifications indicate a pulse energy of 125 mJ and 250 mJ from ArF* and KrF*, respectively, and energies as high as 333 mJ are routinely obtained from ArF*.

The remainder of this article is comprised of reports on recent gas laser research as presented at the gas laser conference. Recent results on the cooling effect on high power visible and UV gas lasers were presented by R. Forestier (Aix-Marseille Univ., Marseille, France). The ability to generate ultraviolet long-pulse laser emission by e-beam excitation of a high-pressure supersonic gas flow at low temperature was first reported in 1978. [R. Forestier and B. Fontaine, "Long-pulse Ultraviolet Laser Emission in an Electron-beam Excited Supersonic Flow," *J. Appl. Phys. Lett.* 32, 569 (1978).] Two supersonic nozzles were used which provided the following gas characteristics: velocity = Mach 1.75, p = 0.45 atm, T = 120 K; and velocity = Mach 2.5, p = 0.20 atm and T = 80 K. A P.I. MX11 Marx Generator operating up to 300 kV and 1500 J with a 600-nsec pulsewidth was used to produce a variable e-beam current density through a titanium foil between 2 A/cm² (5 μsec) and 20 A/cm² (0.5 μsec). In the paper cited above, laser emission from mixtures of Ne:Xe:NF_3 (1000:3:0.7) and Ne:NF_3 (1000:0.7) was reported. At room temperature, emission was composed of a single line at each wavelength, 349, 351, and 353 nm. Upon cooling to 120 K, the 351-nm line disappeared and the 349-nm line spread to a doublet. No explanation was offered for this change in energy distribution among the different laser lines.

Strong laser emission at 348 nm in both Ne/Xe/NF_3 and Ne/NF_3, and at 338 nm in Ne/NF_3 (each at low temperature) was reported in the above reference and identified at the conference as coming from singly ionized Ne. Neither of these lines was observed at room temperature. Also reported at the conference was very strong laser emission from atomic fluorine at several wavelengths near 700 nm. This emission results from excitation of He/NF_3 with e-beam currents as low as a few A/cm². No lasing was observed when the same gas mixtures were similarly pumped at room temperature. Forestier feels that the observed laser lines are a result of an increase of the amplification coefficient and a decrease in the absorption by excited species at the laser wavelength, both a result of cooling. Forestier also pointed out that with the use of aerodynamic cooling they have observed an enhancement on several molecular bands at near UV and visible wavelengths. Also observed was the appearance of new fluorescence bands, not previously reported, when mixtures of rare gases and fluorine, chlorine, oxygen, or sulfur donors were e-beam excited.

Two firsts were reported by K. Hohla (Max-Plank-Gesellschaft, Garching, FRG) in a paper entitled "New Results in UV- and VUV-Lasers: Halogens and Interhalogens." The halogens and interhalogens have recently attracted considerable interest because of the high fluorescence quantum efficiency exhibited by some of these molecules (>10% for I_2). The current list of lasing halogens along with their emission wavelengths is: F, (158 nm), Cl, (253 nm), Br, (292 nm), and I, (342 nm). Hohla reported on the first lasing of F, excited by the TEA (transverse excited atmospheric pressure) discharge configuration. Ultraviolet photo-preionization was employed and an excitation power density of about 50 MW/cm³ was used. Laser emission at 158 nm having

a 0.1 nm width and a pulse duration of 10-15 nsec was observed. The exciting thing about the F_2 laser is that it provides for a high peak-power laser at a shorter wavelength than has previously been available.

Hohla also reported on the first lasing of an interhalogen. Under electron beam excitation (2 nsec, 1 J/cm^3), laser emission (10 mJ) from ClF in the form of two strong lines centered around 284.5 nm was observed. The conclusion that laser action had occurred was based on three criteria: existance of a threshold, spectral narrowing, and temporal narrowing.

J.M. Green (UK Atomic Energy Authority, Culham Laboratory, Abingdon) described a novel technique which provides for the first time fine frequency tuning and narrowing (both effects are implied when the word tuning is used below) of the output of a high-power CO_2 laser. Tuning of CO_2 lasers had been previously realized with the use of germanium etalons; however, because of thermal effects in germanium and the low damage threshold of etalon coatings at this wavelength, such tuning has been limited to relatively low-power devices. Tuning of a high-power CO_2 TEA laser at Culham was accomplished with the use of an intracavity hot cell containing CO_2 gas. The absorption by the CO_2 within the cell falls within the TEA laser gain profile, and the resultant laser emission is composed of two maxima. As the center frequency of the cell's absorption band can be shifted significantly by varying the cell pressure and temperature, the frequency of the two laser maxima can be varied in a controlled manner. The laser output power in the tuned mode is virtually the same as that in the untuned mode. The width of the untuned emission is about 5 GHz (full width at half maximum) and in the tuned mode, a tuning range of ±25 GHz has been realized.

Perhaps the most important near-term application of tunable high-power CO_2 lasers lies in their use as an efficient means of excitation of molecular lasers. In such an approach, essentially all of the power of an untuned laser can be channeled into a narrow band that can be tuned to coincide with one of the absorption bands of the molecular laser. Green reported on the excitation of a CF_4 laser with a CO_2 laser tuned as described above. Even though only one of the maxima was made to coincide with one of the absorption lines of CF_4, the output power of the CF_4 laser was increased by an impressive factor of 200. It is expected that a paper describing this effort will appear in 1979 in *Optics Communications*. Future work on tunable CO_2 lasers at Culham will include the use of an etalon to eliminate the unused maxima. This should result in further enhancement of the excitation efficiency of high-power CO_2 laser-pumped molecular lasers.

Frequently, one of the products of molecular photodissociation is in an excited state, and inversion of the material with respect to the ground state can be achieved. Laser action using molecular photodissociation as the pumping mechanism was first demonstrated in atomic iodine in 1964. Last year, inversion and intense superfluorescence resulting from molecular photodissociation of and halides of Na, K, Rb, Cs, and Tl were reported. N.P. Smith, one of Webb's students, described at the conference the temporal characteristics of the superfluorescence observed in Tl resulting from the molecular photodissociation of TlI. Because of the excimer laser expertise at Oxford, it was only natural that they would use the ArF transition at 193 nm as the source of pump radiation. Their initial observation of emission from Tl at 378 and 535 nm was made quite by accident in that these lines were seen during experimentation on CuI. It was discovered that the CuI was contaminated with about one part in 10^6 of TlI. At this point, experimentation was concentrated on TlI.

Pump energy was limited to less than 100 mJ owing to saturation effects in Tl, and the superfluorescence pulse width was 10 nsec, whereas the width of the ArF pump was 17 nsec. This paper contained the first report of periodic fluctuations in the output of Tl. Fluctuations with a period of 1.2 nsec were observed in both the UV and green lines and at low pump powers, the fluctuations of the two lines being antiphase. As the period of fluctuation does not correspond with the cavity round-trip transit time, the fluctuations cannot be caused by a cavity effect. The origin of these fluctuations is still a subject of some speculation.

Only 4 of the 20 papers presented at the conference have been reviewed in this article. As no proceedings of this conference are to be printed, a number of copies (quite limited) of the Conference Handbook has been made available to ONRL by The Rutherford Laboratory, the conference organizing laboratory. Those desiring a compilation of conference abstracts as contained in this handbook should write to: Office of Naval Research Branch Office, Box 39, FPO New York, 09510, Attn: Richard S. Hughes]

SIGNALS & SYSTEMS

A LABORATORY OF SIGNALS AND SYSTEMS

In 1975, through the amalgamation of several groups at diverse locations, such as the Laboratoire d'Etude des Phénomènes Aléatoires on the campus of the Université de Paris-Sud (PU-S) at Orsay, the Centre National de la Recherche Scientifique (CNRS) established the Laboratoire des Signaux et Systèmes (L2S) at the Ecole Supérieure d'Electricité (ESE) in Gif-sur-Yvette, a couple of miles west of Orsay, in the rural southwestern environs of Paris. The L2S is operated jointly by the CNRS and ESE. Its director is Prof. Bernard Picinbono, widely known for his work in communication theory, random processes, and signal analysis. Picinbono is a former president of the PU-S (also called Université de Paris XI) and an accomplished pianist.

The L2S has a staff of about thirty, who are divided among seven research areas: Signal Analysis, headed by Prof. André Blanc-Lapierre, Director General of the ESE; Systems, under Dr. Pierre Bertrand; Industrial Automation, led by Prof. Daniel Viault, Associate Director of the L2S; Biosystems, under Prof. Raymond Duperdu; Solar Energy and Statistical Optics, both headed by Dr. Christine Benard; and Electromagnetism, led by Prof. Elie Roubine, widely known for his work on antennas. There are, in addition, half a dozen technicians and over a dozen students (some from other countries) carrying on thesis research toward advanced degrees to be conferred by campuses VI and XI of the University of Paris.

Signal Analysis and Communications is the largest of the seven groups, and it includes Picinbono. Blanc-Lapierre is particularly interested in deterministic nonstationary nonlinear systems describable by Volterra series and in related questions of ergodicity. In the area of mathematical modeling his group has obtained various results concerning the ergodicity of second and higher moments of random processes that have a degree of homogeneity in time but may not be stationary, such as the phase of a frequency-modulated signal or of a narrow-band random noise.

Picinbono has considered the exact estimation of the power (second moment) of a random process of known spectral shape. It involves sampling the process and orthogonalizing the set of samples by multiplying by the inverse of the correlation matrix. This works best when the support of the spectrum is infinite, as a record of finite length then effectively permits averaging over an arbitrarily large number of independent variables. Picinbono is also doing related work on signal detection and on noise-controlled automatic gain control. The latter involves linear filtering to remove the signal, to leave a residue whose power is the same whether or not a signal is present. [Cf. B. Picinbono, "Adaptive Signal Processing for Detection and Communication", pp. 639-660 in J.K. Skwirzynski (ed.), *Communication Systems and Random Process Theory*, Sijthoff & Noordhoff, Winchester, MA, 1978 (the proceedings of a NATO Advanced Study Institute; *ESN* 31-10:400, 31-10:402, 32-3:90).]

Other topics treated by this group include spectral analysis and adaptive signal detection and estimation. During the academic year 1977-1978 Prof. Louis L. Scharf of Colorado State Univ., Fort Collins, was at the L2S on sabbatical, investigating the connections between classical methods of spectral analysis and more recent methods utilizing autoregressive and autoregressive moving-average models. He also investigated data reception and phase estimation employing the Viterbi algorithm.

Another well-known member of this group is Dr. Odile Macchi, whose work has dealt with adaptive digital filters, adaptive channel equalization, point processes, and optical-fiber

communication. She has recently turned her attention toward correction of the relatively rapidly changing phase relation between the carrier bringing data through a channel and the reference oscillator at the receiving end. For this purpose, she uses two equalizers in cascade. The first, which has a large number of coefficients (32 in the experimental version), corrects intersymbol interference but is transparent to the phase fluctuations. The second, called the jitter equalizer, is a one-coefficient stochastic-approximation algorithm that can adapt very rapidly to phase and amplitude jitter. Particular attention has been given to correction of the drift due to the frequency difference between the carrier and the demodulating oscillator, which cannot be handled by a classical equalizer. The jitter equalizer takes the place of the phase-locked loops otherwise needed for frequency tracking and thus permits faster operation.

This work is being carried out in collaboration with the Centre National d'Etude des Télécommunications (CNET) in Paris, which will provide a version of the equalizer suited to complex adaptation; the one constructed at the LSS is only a real equalizer. It will be used to handle 14,400-bits-per-second transmission over a telephone line at a 2400-baud rate. This very high bit rate is achieved by using 16-phase differential-phase-shift keying and a choice of 4 amplitudes for each phase, with 12 different amplitude values altogether. (Normal telephone lines ordinarily do not carry more than 9600 bits per second.) Another area of LSS-CNET collaboration--with the CNET laboratory in Lannion, Brittany, in this instance--is Macchi's work on adaptive correction for a wandering notch in the frequency response of a microwave transmission system.

The Systems group is developing increasingly complex models for biological and chemical systems, for transportation and communication networks, and for educational, urban, and economic applications. Their research includes numerical as well as theoretical investigations of control systems, whose complexities often necessitate nonoptimal solutions. System identification is their primary biological problem, while in the chemical field it is the nonlinearity of quantitative chromatography.

The Industrial Automation group's interests are generally in more specific, practical applications, such as the identification of the applicable differential equations and the control of an oven, and the automatic correction of color-television transmitters. The Biosystems group has concentrated on the feminine cardiovascular system in close collaboration with the Centre d'Etudes des Techniques Chirurgicales de l'Hôpital Broussais and the Service de Biophysique du CHU Cochin. With rather limited means, this group has carried out clinical measurements and has developed mathematical models of the heart function and of the pulmonary vascular network, including the effects of pharmacological agents.

The small Statistical Optics group has compared the classical and quantum theories of optical coherence and, partially in collaboration with CNET Lannion, has turned its attention toward optical communication. It has studied channel-capacity and coding problems in the situation where all noise originates in the detector, and it has theoretically investigated the effect of glass-fiber curvature on propagation. Its personnel also serve as the Solar Energy group, in which role they collaborate with the CNRS Groupe d'Etudes Thermiques. In this field their approach is again statistical, developing a mathematical model of the incident solar intensity as a stochastic process in order to determine the appropriate size of an energy collector.

Finally, the Electromagnetic group has been able to support a good deal of thesis research on diffraction and propagation despite its having to share the time of all of its staff members with various academic activities. Current work has concerned radiation by apertures and dielectric media, all of which have been investigated both experimentally and through calculation. The experimental approach had lagged because of a lack of equipment and facilities, but this problem is now fairly well corrected.

The LSS is still in the process of unifying the various groups that it has brought together, which represent diverse levels of personnel and resources as well as distinct interests. But, it includes a number of very good, very well-known people, whom it shares with various campuses of the Univ. of

Paris and with the ESL. It can be anticipated that, because of their advancing years, Blanc-Lapierre and Roubine will soon retire, but Picinbono and others can be expected to maintain the high quality of the L2S's work. (Nelson M. Blachman, GTE Sylvania Inc., Mountain View, CA)

NEWS & NOTES

EUROPEAN UNDERSEA BIOMEDICAL SOCIETY 5TH ANNUAL SCIENTIFIC MEETING

The 5th Annual Scientific Meeting of the European Undersea Biomedical Society was held in Bergen, Norway, on 5-6 July 1979. There were a total of 29 presentations and over 150 participants were registered. Also included in the program was a full afternoon tour of the facilities and selected projects of the recently opened Norwegian Underwater Institute (NUI), Norway's leading research establishment in the fields of underwater technology and physiology.

Topics to which papers were addressed included: Norwegian and Swedish diving safety philosophies; hyperbaric evacuation; overview of ongoing research in Norway; air decompression table optimization work; pathology associated with diving accidents; bubble detection after isobaric gas switches; effect of oxygen breathing after diving and before flying; tissue impedance method of detecting bubbles; neuropathology of decompression sickness lesions (DCS) in goats; hematological and biochemical changes in a group of North Sea divers; red cell and perceived termperature sensation changes during deep heliox dives; effects of high oxygen tensions and increased ambient pressure on circulation; exercise ventilatory capacity at depth; a microprocessor to attempt energy expenditure estimation in working divers; nitorgen metabolism during deep saturation dives; review of dysbaric osteonecrosis; changes in xenon-133 clearance from rabbit bone marrow and skeletal muscle during simulated dives; value of scintigraphy in dysbaric osteonecrosis; transcutaneous measurement of oxygen partial pressure during diving experiments; increase of neuroamines related to hyperoxia; ear clearing in divers; bubble detection following heliox bounce dives; and possible attentuation of hyperbaric hyper-reflexia by nitrogen.

For more information, refer to the complete meeting to be published in a forthcoming ONRL conference report. (LCDR R.F. Goad, MC, USN, Exchange Office in Underwater Medicine, Institute of Naval Medicine, Alverstoke, Gosport, Hampshire, UK).

A JACK-IN-THE-BOX WEATHER STATION

Drs. G. Peckham and J. Barton, Meteorologists in the Physics Department of Heriot-Watt University in Edinburgh, are working on the second generation of automatic weather stations for use on the tops of the highest mountains in Scotland. The prototypes have become encased in solid blocks of ice in the winter and became inoperable for long periods of time.

The current models of the weather stations, on Cairngorm Summit, north of Edinburgh, are about the size and shape of a 55-gallon oil drum. The meteorological sensors are fastened to a framework under the lid of the case. Most of the time the case is closed with the sensors inside. The case is heated electrically so that no ice will form on it, the electricity coming from the Cairngorm ski lift. Whenever it is time to make observations, a timer triggers a mechanism that pushes both the frame holding the sensors and the lid to the case up above the case so that the sensors are exposed to the weather and observations can be made. The sensors are then lowered into the heated case and the lid closes to wait for the time of the next observation. The data obtained is sent by shortwave radio to manned stations at lower altitudes. (Wayne V. Burt)

THE NORWEGIAN UNDERWATER INSTITUTE, BERGEN, NORWAY

The newly completed Norwegian Underwater Institute (NUI) representing an investment of approximately $6 million, is located just around the corner from the excellent harbor in Bergen, Norway, and it is a major center of underwater technology research and development in Norway, particularly that dealing with off-shore oil development. Bergen is one of the busiest shipping ports in Scandinavia and is located within a short distance of Norwegian off-shore activity.

The Institute is organized as an independent, nonprofit organization which is dedicated to research and development in manned and unmanned underwater science and technology. The ownership of the Institute is 50% by the Royal Norwegian Council for

Scientific and Industrial Research (NTNF) and Det Norske Veritas, a private industrial certification organization. This arrangement provides a great deal of flexibility and allows the Institute both to solicit and respond to existing research needs and opportunities in these areas. Its Director, Dr. Øystein Martinsen, previously with COMEX, is vigorously pursuing this approach.

The Institute, situated right on the water in a sheltered cove, is well laid out with all support facilities tangentially arranged on several floors so that quick access to the main hyperbaric facility is readily available. Administratively, NUI is organized into four main sections dealing with: 1) medical physiological problems; 2) safety and training; 3) underwater instrumentation systems; and 4) facilities and technical testing. Several projects now ongoing in each of these sections are being pursued with considerable collaboration with different research and development groups in the Bergen area and throughout Norway.

One of the striking attributes of the very newly formed Institute is, in fact, the extent to which it has availed itself of outside interest and consultants in a number of projects. Thus, it has quickly moved up to the state-of-the-art awareness in all of these areas and is now a major world center of this activity. Again, the nature of its organization and mission makes this much more efficient than would a similar institute housed either under the shelter of a government lab or alternatively as a university offshoot. Both the practical and theoretical approach are well mixed, and this always provides a healthy environment.

Particularly promising at the present time from the point of view of diving safety is the underwater instrumentation group headed by Sturle Søvik which has several projects dealing with alternative techniques for biomedical gas monitoring, acoustic bubble sensing, and ventilation measurement as well as underwater communications. Thus, the Institute has collaborative programs with University of Bergen, adjacent hospitals, Christien Mickelson Institute in Bergen, and several laboratories in the United States. Also, the physical organization of the laboratory in providing all required facilities, library, and lounge as well as its proximity to Bergen all contribute to efficient transfer of information between and within different specialites.
(Brian G. D'Aoust, Director, Hyperbaric Physiology, Virginia Mason Research Center, Seattle, WA)

ONRL NEWS

The last of August was the departure of three of our scientific staff, however you will still be hearing from them through the pages of ESN for several months to come. We bade farewell to:

Dr. Martin Lessen (Mechanical Engineering) who has returned to his former position as Yates Memorial Professor of Engineering of Mechanical and Aerospace Engineering at the University of Rochester.

Dr. Jeff Perkins (Materials Science/Metallurgist), who has returned to the Naval Postgraduate School, Monterey, CA as Associate Professor of Materials Science in the Department of Mechanical Engineering.

Dr. Robert W. Rostron [Physicist (Space)], who has returned to his former position with the Defense Communications Agency in Washington, D.C.

We wish them bon voyage and smooth sailing!

PERSONAL

The Institute of Physics has elected the following members as Honorary Officers and Members of Council:

Vice-President - Dr. J. Goddard (City of London Polytechnic); Honorary Treasurer - Prof. J.M.A. Lenihan (re elected; Honorary Secretary - Prof. E.R. Dobbs (re-elected); and Ordinary Members of Council - Prof. P.K. Carroll (Univ. College of Dublin), Prof. P.T. Landsberg (Univ. of Southampton), and Sir Ieuan Maddock FRS (British Association for the Advancement of Science, London).

Dr. T.J. Briscoe, Professor of Physiology, Bristol Univ. Medical School, has been appointed to the Jodrell Chair of Physiology, University College, London, from 1 August.

For the first time since it was created 1666, the French Academy of Sciences has elected a woman member, Dr. Yvonne Choque Bruhat. Mrs. Choque-Bruhat has been a full professor at the Paris Faculty of Science and then at the Univ. of Paris VI where she teaches analytic mechanics and celestial mechanics.

Dr. D. Mara, Senior Lecturer in Civil Engineering, Univ. of Dundee, has been appointed to the newly created second Chair of Civil Engineering at the Univ. of Leeds, from 1 October.

OBITUARY

Feodor Lynen, Nobel Laureate in Medicine and Physiology in 1964, died in Munich 8 August at the age of 68. He was a pioneer in fatty acids research and was awarded the Nobel Prize for his research into organic metabolism. He was Director of the Max-Planck-Institute für Zellchemie in Munich.

R-3-79 THE FLEISCHNER SOCIETY CHEST SYMPOSIUM by I.M. Freundlich

The annual Symposium of the Fleischner Society is the major event of the year in chest radiology. The society's multidisciplinary approach is conducive to important papers and symposia concerning chest disease that may bear only indirectly on the practice of radiology. While there was no single unifying theme, the meeting was highlighted by Sackner's review of his work on the mucociliary transport mechanism in asthma, Weibel's impressive lecture on the microstructure of the lung and its relationship to pulmonary physiology, and West's plans for future experiments during weightlessness.

R-4-79 THE DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF LIVERPOOL, by W. Burt

The Department of Oceanography at the University of Liverpool is the oldest of the three oceanography departments in the UK. Its research is largely in physical oceanography and marine analytical chemistry. A full range of courses is offered in physical and chemical oceanography. Students are working for undergraduate honors degrees in oceanography and the MS and PhD degrees.

R-5-79 *EUROPEAN FIBRE OPTICS*: A COMPLETE REPORT OF THE JUNE 1978 SURVEY by D. Williams, D. Hart, T. Meador, A. Glista, E. Allard (Proprietary information distribution limited to US Government agencies only)

This report documents the findings of a series of visits to industries working on fibre optics technology in Europe. Thirteen companies in five countries were visited. These companies' activities range from limited involvement in component development through entire fibre optics systems development and research on all related technologies. A massive effort is represented by the collective activity and investment being dedicated to this emerging technology in Europe. Present and future activities of these companies deserve further evaluation from military research managers who may be planning to make use of fibre optics technology for military applications.

INDEX OF ONRL TECHNICAL AND CONFERENCE REPORTS, 19??

Now that all ONRL Technical and Conference Reports published during 19?? have been accessioned by the Defense Documentation Center, we are pleased to provide this index. Copies of these reports may be obtained from either the Defense Documentation Center, Cameron Station, Alexandria, VA 22314 or the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, by using the listed AD number.

BIOLOGICAL SCIENCES

ONRL C-3-??	J.B. BATEMAN	Electrical Phenomena in Biological Membranes (AD-A041442)
ONRL C-11-??	L.S. AUGUST	Third Symposium on Neutron Dosimetry in Biology & Medicine, 19?? (AD-A046020)
ONRL C-14-??	J.B. BATEMAN	Microwave Magic (AD-A048060)
ONRL R-8-??	J.B. BATEMAN	Acute Rhabdomyolysis from Eating Quail (AD-A045007)

ELECTRONICS

ONRL C-5-??	N.M. Blachman	Direct Satellite Broadcasting (AD-A042921)
ONRL C-18-??	D.A. HART	Radar ?? (AD-A053624)
ONRL R-4-??	N.M. Blachman	Communication Engineering in Finland (AD-A040264)

ENERGY

ONRL R-5-??	A. SOSIN	European Developments in the Na/S High Temperature Battery for Automobile Propulsion and Energy Storage (AD-A042541)
ONRL R-6-??	W.G. SOPER	Efficiencies of Various Methods for Solar Energy Conversion (AD-A042584)

ENGINEERING

ONRL R-1-??	R.H. NUNN	The Marine Gas Turbine—The UK Provides a Case Study in Technological Development (AD-A037686)
ONRL R-3-??	S.C. KUO R.T. SCHNEIDER	Closed Cycle Gas Turbine Systems in Europe (AD-A040250)

ONRL R-10-77	A. BARCILON	Research in France (AD-A046018)

MATERIAL SCIENCES

ONRL C-1-77	P.C. TAYLOR	Symposium on the Structure of Non-Crystalline Materials (AD-A037648)
ONRL C-7-77	W.M. CATHEY	Hydrogen in Metals Conference, Paris, June 1977 (AD-A046019)
ONRL C-9-77	J. PERKINS	ICOMAT 1977 International Conference Martensitic Transformations, Kiev, USSR, 16-19 May 1977 (AD-A045007)
ONRL R-2-77	A. SOSIN	Materials Research at Universities--In France et Found in Deutschland (AD-A040263)
ONRL R-14-77	A. SOSIN	Photoemmission Electron Microscopy: Another Powerful Tool for the Microscopist (AD-A038860)

MATHEMATICAL SCIENCES

ONRL R-11-77	N.M. BLACHMAN	Information Theory in Hungary (AD-A050788)

MEDICINE

ONRL C-10-77	R.I. WALKER	Sixth Annual Conference of the International Society for Experimental Hematology, Basel, Switzerland, 28-31 August 1977 (AD-A050787)
ONRL C-19-77	D. WHIPPLE	North American-European Health Systems Research Conference (AD-A049972)

OCEAN SCIENCES

ONRL R-7-77	J.P. SIMPSON	Preliminary Description and Specifications for a Danish Coastal Marine Data Collection System (AD-A043693)
ONRL R-9-77	R.N. CORDY	Liaison Technologist Program, Ocean Facilities (AD-A045078)

PHYSICAL SCIENCES

ONRL C-2-77	P.C. TAYLOR	XIIIth International Semiconductors Conference (1976) (AD-A039601)
ONRL C-4-77	J.S. SCHILMAN	Conference on Luminescence Processes in Cathod-Ray Tubes and Lamps, Weybridge, Surrey, 29-31 March 1977 (AD-A041443)
ONRL C-6-77	W.G. SOFER	Fifth International Symposium on Military Applications of Blast Simulation (AD-A042575)
ONRL C-8-77	D.A. HART	Colloquium on Optical Fiber Cable, Institution of Electrical Engineers (U.K.) (AD-A043637)
ONRL C-12-77	V.N. SMILEY	Optical Fibers, Integrated Optics and their Military Applications London (AD-A045704)
ONRL C-13-77	S.G. BISHOP T.L. REINECKE U. STROM P.C. TAYLOR C.C. KLICK	Seventh International Conference on Amorphous and Liquid Semiconductors at Edinburgh (AD-A050789)
ONRL C-15-77	A. ROBERTS	Acoustic Detection of Neutrino Interactions in the Ocean: The 1977 Dumand Summer Workshop, Moscow, 26-28 June 1977 (AD-A048061)
ONRL C-17-77	H. RUSKIN R. CHERRY	The Thirteenth IUPAP Conference on Statistical Physics (AD-A050790)
ONRL R-12-77	E.C. ESSIG	Millimeter Wave Technology in Europe--Fall 1977 (Distribution limited to U.S. Government Agencies only) (AD-B026692L)
ONRL R-13-77	E.C. ESSIG	A View of Surface Acoustic Wave Technology in the U.K.--Fall 1977 (Distribution limited to U.S. Government Agencies only) (AD-B026063L)

PSYCHOLOGICAL SCIENCES

ONRL C-16-77	J.A. ADAMS	NATO International Conference on Experimental and Behavioral Approaches to Alcoholism (AD-A050329)

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